AD-A100 658 FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTE--ETC F/G 4/1
ATMOSPHERIC DUST AND AEROSOL STUDY.(U)
APR 81 R REITER, H MUELLER, R SLADKOVIC DA-ERO-77-G-035
UNCLASSIFIED NL

1 OF 1
AD A
100658

END
DATE
FILMED
7-81
DTIC

(12) LEVEL II

AD

ATMOSPHERIC DUST AND AEROSOL STUDY

Data Report

by

Reinhold Reiter,
Hans Müller
and Rudolf Sladkovic

DTIC
ELECTE
JUN 26 1981
S D
B

April 1981

ADA100658

EUROPEAN RESEARCH OFFICE
United States Army
London, England

Grant Number DAERO – 77 – G – 035

Fraunhofer Institut für Atmosphärische
Umweltforschung

Kreuzeckbahnstraße 19
D-8100 Garmisch-Partenkirchen

DTIC FILE COPY

Approved for public release;
distribution unlimited.

81 6 25 012

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER / 2. GOVT ACCESSION NO. AD-A100658	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Atmospheric Dust and Aerosol Study. Data Report	5. TYPE OF REPORT & PERIOD COVERED DATA REP[redacted]T Marc[redacted] 76 — Dec[redacted] 78
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Reinhold Reiter, Hans Müller, Rudolf Sladkovic	8. CONTRACT OR GRANT NUMBER(s) DAERO-77-G-035
9. PERFORMING ORGANIZATION NAME AND ADDRESS Fraunhofer Institut für Atmosphärische Umweltforschung, Kreuzeckbahnstrasse 19 D-8100 Garmisch-Partenkirchen, West Germany	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS IT161102BH57-01
11. CONTROLLING OFFICE NAME AND ADDRESS USARDSG-UK Box 65, FPO New York, NY 09510	12. REPORT DATE Apr[redacted]81
	13. NUMBER OF PAGES 53
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Aerosols, atmospheric particles, tracers, dispersion, meteorology, atmospheric sampling, atmospheric dust, Rotored samplers

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fluorescent particle tracer experiments have been conducted to study the dispersion processes in the north-alpine Loisach River Valley for a variety of meteorological conditions including inversion cases. This report summarizes the details of the experiments and presents all results, in particular the particle concentrations measured at various downwind locations by H-shaped Rotorod samplers together with the relevant meteorological conditions, in tabular form. The report is intended to serve as a data base for further analysis.

AD ____________

ATMOSPHERIC DUST AND AEROSOL STUDY

DATA REPORT

by

REINHOLD REITER
HANS MÜLLER
RUDOLF SLADKOVIC

April 1981

European Research Office
United States Army
London England

Grant Number DAERO -77-G-035

Fraunhofer Institut für Atmosphärische
Umweltforschung
Kreuzeckbahnstrasse 19
D-8100 Garmisch-Partenkirchen

Approved for public release; distribution unlimited

Table of Contents

		page
	ABSTRACT	1
1.	INTRODUCTION	1
1.1.	General	1
1.2.	Survey of Literature with Conclusions as to the Concept of our Studies in the Loisach Valley	2
2.	SITE DESCRIPTION	6
3.	EXPERIMENTAL DESIGN	7
3.1.	Tracer Material	7
3.2.	Release	8
3.3.	Sampling	9
3.4.	Assessment	10
3.5.	Errors	11
4.	DATA SUMMARY	12
4.1.	General Survey	12
4.2.	Contents of Tables	13
5.	FINAL REMARKS	15
6.	REFERENCES	16
	PRESENTATION OF ALL EXPERIMENTAL DATA	25

Availability Codes

Dist	Avail and/or Special
A	

ABSTRACT

Fluorescent particle tracer experiments have been conducted to study the dispersion processes in the north-alpine Loisach River Valley for a variety of meteorological conditions including inversion cases. This report summarizes the details of the experiments and presents all results, in particular the particle concentrations measured at various downwind locations by H-shaped Rotorod samplers together with the relevant meteorological conditions,in tabular form. The report is intended to serve as a data base for further analysis.

1. INTRODUCTION

1.1. General

This Data Report is preceded by four reports (see list of reports on the Loisach River Valley tracer field studies page 19), containing first the geographical conditions under which the field experiments took place, further the technical equipment used in operation, and finally step by step the first results of the tracer experiments and of simultaneously performed meteorological measurements. Some theoretical evaluations have likewise been reported.

The purpose of the present Data Report is to describe the experimental design - following the survey of literature relevant to our subject (1.2.) - and to present all measured data in tabular form according to a uniform scheme,thus allowing interested research groups to readily use our data for further treatment.

This data collection is preceded by:

i. a detailed description of the topography of the terrain where the measurements have been made;

ii. experimental particulars of the tracer material, of the aerosol generator and of the samplers used;

iii. Guide for the use of the data compilation.

We intend to process the present data theoretically in a separate, additional study (after submission of a proposal) within the frame of an extended Gaussian model.

At this point the first author wishes to point out that the feasibility of the experimental study was based on two requirements:

1. The interest of the research group at US Army Dugway Proving Ground, Utah (later White Sands Missile Range) where we are particularly indebted to Don L. Shearer as initiator and Mr. H.E. Cramer, and
2. the existence of an isolated and centrally located hill (peak 300 m above the valley floor) at the opening of the Loisach Valley to the pre-alpine region. This hill enabled us to operate on its peak the aerosol generator provided to us by the US Army Dugway Proving Ground and to release the aerosols downwind into the valley.

I should like to express my sincere thanks for any kind of help rendered to us, especially for many fruitful discussions at the Dugway Proving Ground.

1.2. Survey of Literature with Conclusions as to the Concept of our Studies in the Loisach Valley

Describing the short-term dispersion of air pollutants the most widely used concept relies on the Gaussian plume model (e.g. Stern et al., 1973) and, along with this, on appropriate 'turbulent diffusion-typing schemes' (more recently reviewed by Gifford 1976 a,b). Since this semi-empirical approach largely depends on stationary and horizontal homogeneous flow patterns, its successful use is preponderantly restricted to flat terrain, where those well-behaved air currents are governed 'to a good degree by the pressure, Coriolis, frictional and buoyancy forces' (Kao et al., 1974).

In mountainous terrain, however, a large variety of thermally and orographically induced 'local windsystems' (e.g. Defant 1951; Flohn, 1969; Yoshino, 1975) may additionally develop, and the complexity of these terrain-dominated flows often degrades predictions by the Gaussian plume model (or comparable assessment techniques) to those of minor or minimal credibility. There is an urgent need, therefore, to develop appropriate terrain-related diffusion and transport models and, in supporting this, to intensify the experimental research on 'terrain-induced airflow phenomena' (Barr et al., 1977).

Of special interest in this connection are tracer field studies. Very valuable insights into the plume behavior, especially in the case of deep canyons, have been gained so far by Start et al. (1974, 1975), Hovind et al. (1974) and, more recently, by Archuleta et al. (1978). Start and co-workers, e.g., when comparing measured canyon dilutions with 'standard flat terrain curves' (according to the usual Pasquill-Gifford (PG) categories), found the observed concentrations systematically lower, with differences ranging from a factor of 1.4 (during moderate to strong temperature lapse, B category) to about 5 (for neutral stability, D category) to 15 (during strong inversion stabilities, F category). Similar departures are reported by Hovind et al. for 'the canyon site A' with the respective factor amounting to about 10 for conditions of category F ('stagnation conditions' in the winter), see also Gifford (1976a). Some controversy has been raised by Tank (1976),who, in reexamining the results of Start et al. (1975), demonstrated the D category classified cases to be better represented by conditions 'intermediate to C and D stability' and who succeeded in showing 'a near perfect (in a statistical sense) agreement between theory and observation' when the appropriate version of the Gaussian plume model is applied to the data. According to Tank this agreement is not too surprising when considering that 'only

those disturbances of scales comparable to, or less than, the dimension of an actual effluent plume can contribute to plume diffusion', or when realizing that enhanced diffusion rates may only be expected if 'topographically induced flow disturbances can actually begin to participate in the diffusion process'.

In intermediate topographic settings, e.g. in case of mountain-vally terrains, well-ordered airflow patterns with marked divergence fields may be involved in the dispersion. This has been particularly well demonstrated by Kao et al. (1974), who investigated the windfield in the Salt Lake Valley area and, in this frame, studied the propagation of 'marked air particles' (by trajectory analysis methods). Kao et al. found the rate of diffusion varying in time and space within a mean motion strongly affected by the mountain-valley winds. Thereby, horizontally convergent flow has been ascertained with mountain winds, and horizontally divergent flow with valley winds. Fosberg et al. (1976) also point to this topic and propose a 'divergence correction' to be applied to the Gaussian plume model. The authors show that for realistic estimates of the 'toposcale' divergences this term would reduce the concentration maximum by a factor of more than 2. Reid (1979), who studied the propagation of ice nuclei in the Eagle River Valley near Climax (Colo.) during winter months, draws attention to the frequent occurrence of 'shallow diabatic flows' developing under very stable conditions ('capping inversions') and, with regard to these conditions, doubts the successful applicability of the Gaussian models to 'mountain-valley dispersion problems'. The special behavior of temperature structures in a deep mountain valley (Gore River Valley near Vail, Colo.), especially the destruction of the ground-based inversion after sunrise, has been investigated by Whiteman and Mc Kee (1977). The importance of the observed 'descent of the top of the inversion' with regard to the dispersion of air pollu-

tants has been elucidated by the same authors in a more recent paper (Whiteman and McKee, 1978). Therein, a new model - relying on the 'inversion descent hypothesis' - is described, which allows the prediction of the time-dependent concentration along the sidewalls, and which is a promising attempt to consider well-founded results on the matutinal break-up mechanism of nocturnal ground-based inversions.

Although considerable progress in understanding the fundamental processes in mountain diffusion meteorology has thus been achieved in recent years, there is a definite lack of specific tracer field studies especially in 'normal', medium-sized, mountain valleys.

The Loisach River Valley, with the Institute for Environmental Research being located near its head, belongs to this type of valley. It is U-shaped, 20 km long and 2 km wide and is located approximately 100 km south of Munich (Figure 1). It is characterized by a distinct mountain-valley wind system (Reiter, 1965), with daytime north-eastern (NE) up-valley winds and nighttime south-western (SW) down-valley winds. During the period between May 1975 and July 1976, fourteen diffusion experiments were carried out in this area. Fluorescent particles were used as atmospheric tracer and an array of H-shaped Rotorod samplers as collecting system. The plan to accomplish tracer measurements has been considerably promoted by the existence of an isolated hill (300 m abg) in the immediate vicinity of the valley entrance (Figure 3), an unique topographical feature inviting to release the tracer from its top. With the tracer released at the valley entrance our primary objective has been to investigate the aerosol transport along and across the valley under a variety of characteristical, but different, meteorological up-valley wind conditions.

Generally, most samplers were installed at various downwind

locations at the valley floor, in several cases, however, some few devices were also run at selected mountain sites (Wank peak and sites labeled by roman numbers (I - VI) in Fig. 1).

For each experiment comprehensive meteorological information was provided: i) by the permanent meteorological measuring facilities at the Institute (indicated by an 'I' in Fig.1) and the surrounding high mountain observatories Wank and Zugspitze; ii) by special pibal tracking (windfield) and radiosonde ascents (temperature) at several locations in the valley prior to, during and after each experiment (the arrangement may be seen from Fig.4). Cloud cover, radiation conditions and other relevant parameters were also included to gain further insight into the diffusion meteorology.

2. SITE DESCRIPTION

The topographical features of the Loisach River Valley suggest a distinction of the main valley into two parts (Fig.1):

The northern part extends from the northern end of the Garmisch basin to the Höhenberg 'release' mountain (indicated by an 'H' in Fig.1). Length, width, and relative ridge-height of this SSW-NNE oriented section amount to 10 km, 1800 m and 1000 m, respectively. The valley widens immediately north of the Höhenberg and then enters the 'Murnauer Moos' fen or the Bavarian pre-alpine region in a funnel-shaped way.

The Garmisch basin may, on the other hand, be conveniently defined as the area enclosed by the 800 m contour-line and the line segment Wank-Kramer. Hence, the Garmisch basin shows a considerably deviating direction, it runs from WSW to ENE, is 7 - 8 km long and approximately 2 km wide. In the south it is surmounted by several ranges of the Wetterstein massif

with the Zugspitze (3000 m a.s.l.) being its highest peak. Since the main ridge raises to 2600 m height or almost 2000 m above the valley floor, the southern ranges are by far the highest of all surrounding mountain chains including those of the Kramer complex in the northwest.

The walls of the main valley are forested up to the timberline at about 1700 m a.s.l.; the sloping, however, varies considerably from place to place, only the eastern flank (Estergebirge) of the northern part shows a fairly homogeneous structure with an inclination of approximately 30° to a height of 1300 m above the river.

The nature of the valley floor is characterized by meadows, small forests and urban districts (Fig.2) marking this area as one of considerable inhomogeneous aerodynamic roughness.

This description is completed by two pictures taken from different locations: Figure 2 shows the view from the Höhenberg over the northern part of the valley elucidating both the patchiness of the valley floor and the afforestation of the walls. Conversely, Fig. 3 shows the view from the Wetterstein range towards NE, thereby demonstrating the isolated location of the Höhenberg ('H') at the valley entrance.

3. EXPERIMENTAL DESIGN

3.1. Tracer Material

The tracers were zinc sulfide fluorescent particles (FP) from the United States Radium Corporation (USCR).
The tabular survey shows the main material properties: Color, particle density PPG (particles per gram), mass median diameter MMD, and the particle size distribution.

Type: 2210 Green/Lot H-1096

PPG : 0.91×10^{10}

MMD : 3.6 µm

Diameter (Microns)	Percent
< 0.75 µm	5.0
0.75 - 5.5 µm	92.9
> 5.5 µm	2.1

Physical characteristics of FP tracers

This type of material was used in the first 8 experiments, thereafter another lot (Lot 15) with similar characteristics (PPG = 0.92×10^{10} , MMD = 3.2 µm was used).

3.2. Release

The dissemination of the aerosol was accomplished by a Metronics Model 8 Blower Generator of the series'widely used in the field'(Leighton et al., 1965). With regard to the forested area, however, a direct release was inappropriate. Instead of this, the particles were released via a tube extending to the tree top height (8 m). The 'blowing nozzle' at the tube's end can be seen from Fig.2.

Following Leighton et al. (1965) and, therefore, denoting 'the number of particles made airborne per unit weight by F_s and the weight of FP fed through the generator by W, the source strength or the number of particles released is given by the product $W \cdot F_s'$. Hence, the release rate is $Q = (W \cdot F_s)/\tau$ or

(1) $$Q = \frac{W}{\tau} \cdot F_s,$$

τ being the duration of the release.

With τ varying between 40 and 60 min, a constant feed rate of

$$(2) \qquad \frac{W}{\tau} = 85 \text{ g min}^{-1}$$

was used in all experiments assuring sufficient coverage in all cases.

Assuming a dispersal efficiency close to unity, F_s is approximately reflected by the 'number of primary particles in the undispersed state (PPG)' (Leighton et al, 1965). Hence, with the PPG-values of the tracer material used, the emission rate Q is obtained as:

$$(3) \qquad Q \approx 1.3 \times 10^{10} \text{ particles s}^{-1}.$$

In the further treatment of the data, e.g., when deriving the relative concentrations S/Q, this value is to be used for all experiments.

3.3. Sampling

Tracer samples were collected using H-shaped Rotorod samplers. These were no Metronics fabricated devices but, in fact, the Metronics standard type (as described by Grinnell et al., 1965, or Leighton et al., 1965) was reproduced by our laboratory, with a total of 20 devices.

According to the operational design, i.e.,'with two collecting surfaces of $A = 0.38 \times 60 \text{ mm}^2$, a rotation radius of 60 mm and a rotation speed of 2400 rpm (corresponding to a speed of the collector arm of $v = 2\pi \times 6 \cdot 40$ cm/s = 15.1 m/s)' (Leighton et al., 1965), the apparent sampling rate $F_r' = 2 \cdot A \cdot v$ is estimated to

$$(4) \qquad F_r' = 41.3 \text{ l min}^{-1}.$$

This value is modified by considering the Rotorod efficiency η, which amounts to about 65% for the particle size range used in these experiments and with rods coated according to standard procedures. Hence, for actual dosage determinations the true sampling rate $F_r = \eta \cdot F_r'$ is to be applied, namely:

(5) $F_r = 26.9 \text{ l min}^{-1}$.

Before each experiment the collector arms of the Rotorods were 'manually coated' with special silicone grease according to the recommended standard procedure (e.g. Grinnell et al., 1965).

During the experiment all samplers were fixed to metal posts at approximately one meter above the ground, as is common practice in comparable field trials (e.g. Archuleta et al., 1978).

The samplers were operated on specially designed 9-volt d.c. battery systems providing constant rotation speeds (with a constancy better than that of the standard version ($\pm$2%) during a several hours run).

The samplers were energized just prior to a release. After cloud passage the period of operation was 'held to a minimum in order to avoid obscuration of FP by atmospheric particulates deposited after cloud passage' (as has been recommended by Leighton et al., 1965).

3.4. Assessment

After each experiment the particles on the collector rods were counted by means of a Zeiss microscope of magnification 160x (10 x eyepiece and 16 x objective of 0.35 N.A.) with incident UV light (to excite the fluorescence).

In most cases the population proved to be of low density (with particles less than 1000) and, therefore, no 'specific area counting with reticle grids' (as is common practice in case of medium and high-density rods , e.g. Archuleta et al., 1978; Leighton et al., 1965) was applied in visual counting, but the entire collecting surface was scanned to obtain the total count.

3.5. Errors

The operational errors inherent in the FP technique have been carefully studied and reviewed by Leighton et al., (1965).

According to this, in dissemination with the blower generator, the main error in source strength determinations originates 'in the uncertainty of the value used for F_s'. This error, expressed in terms of 90% confidence intervals, was found to be of the order of ±5-10%.

The random errors in sampling and assessment typically prove to be in the order of ±10-12% (for 300 particles counted). These values of the 90% confidence intervals, which are based on 'close array experiments and an assumed Poisson distribution', increase to approximately 20% and 30% for particle counts of 100 and 30, respectively; sample counts of fewer than 10 particles are recommended to 'be regarded as not significant'.

We found the differences in the counts of the two collecting surfaces (whose sum yields the total count) within these limits.

4. DATA SUMMARY

4.1. General Survey

A survey on the experimental specifics - release data, meteorological conditions, number of samplers at different areas of interest - is given in Table 1.

As to the propagation meteorology, the stability class was determined by the most widely used diffusion categorization scheme discussed by Pasquill (1961) and Turner (1961), and the mean flow was specified by an average wind speed between ground level and 300 m height (source level) deduced from the pibal measurements. According to this, the stability ranged between B and D categories, and the windspeed varied between 3 and 7 m/s. Most (10) experiments were conducted during the summertime with well-developed up-valley winds, whereas the remaining four experiments represent winter/ spring cases with partly complex meteorological conditions (inversion structures and in one case (No.12) unsteady winds).

The column 'number of samplers at....' in Table 1 was added to show at a glance what part of the area had been of primary interest in the specific experiment.

Anticipating the more detailed Tables I - XIV, Table 2 surveys the experiments with three and more samplers at the mountain sites (the locations are specified in Fig.1 by roman numerals from Wamberg I to Kreuzeck VI). The table is intended to show the orders of magnitude of the mean concentration S [particles m^{-3}], where S is defined as the quotient of measured true dosage and sampling time (duration) τ (see 4.2.). The comparison with the (maximum) exposures at the Garmisch basin (valley floor) indicates, that occasionally substantial particle concentrations may be found at the mountain sites even at considerable lateral distances (in the last column y

denotes the lateral distance from the ground-level plume centerline); in case of experiment No.13 the concentration was even higher at most mountain sites. Appropriate interpretations are only possible with the results from auxiliary aerological soundings.

4.2. Contents of Tables

The results of the 14 experiments are summarized in Tables I - XIV, with all tables designed in the same way.

The upper part of each table contains information on the duration of emission, the mainly investigated area, and the meteorological conditions.

To specify the windfield, the results from the individual pibal stations - with bases at normally two locations (depending on the area of primary interest) - are included; the respective mean values are denoted by $\bar{u}_1$ and $\bar{u}_2$ and were used to derive the mean windspeed U. Since the aerological results have been extensively illustrated in previous reports, none of those figures have been reproduced here; to complete the compilation they are frequently referred to in the tables, however. In order to facilitate a search, the respective report is referred to at the legend to each table.

The data of the tracer measurements are summarized in the lower part of each table.

The positions of the individual samplers (denoted by capital letters) are orientated at the ground-level plume axis (time mean path) and defined by the distances 'along the axis (x)' and in the 'lateral direction (y)'. A topographical map (scale 1:25 000) has been used to localize the plume centerline (location of maximum exposure).

Figures I - XIV show the respective centerlines together with the sampler locations and the particle counts for each experiment. The tabular description of the sampler locations is completed by the columns 'altitude above sea level' and 'height difference source - sampler'.

The particle counts are denoted by D_τ, where the sampling time τ (min) is indicated by the index.

The particle counts D_τ were used to determine the mean particle concentration S_τ according to:

$$(6) \qquad S = \frac{D_\tau}{F_r \cdot \tau} \quad ,$$

where F_r = 26.9 l min^{-1} (see Eqn.5).

In the tables, S_τ concentrations are converted into particles m^{-3}.

When discussing dosage or concentration measurements, the Gaussian plume model is often used as reference. This frame implies the incorporation of (empirical) dispersion coefficients, whose values are, however, mostly based on sampling or averaging times of about 10 min (e.g. Turner, 1970). In order to provide a data set which may conveniently be compared with standard model entries, the S_τ concentrations were converted according to:

$$(7) \qquad S_{10} = S_\tau \ (\tau/10)^{0.2} \ , \ \tau \ [min] .$$

In case of τ = 60 min, the S_{60} values have to be multiplied by 1.43, a conversion factor well known in diffusion meteorology.

The last column contains the product S·U with units of a particle flux, $P/(m^2 s)$. Using the emission rate Q (see Eqn.3, page 9) one immediately obtains the 'wind-speed-normalized

relative concentration' SU/Q (with units of m^{-2}), which may be the most convenient entry when comparing dilution rates.

5. FINAL REMARKS

The data set of FP tracer dosages obtained from samples at ground level (valley floor) and surrounding mountain sites provides a base for further analysis of the dispersion processes in a mountain valley for a variety of meteorological conditions including inversion cases.

Since the dispersion is believed to be related not only to small scale turbulence but also to 'organized' divergence fields occurring within the mesoscale mountain-valley wind circulation (e.g. Fosberg et al., 1976), any forthcoming data analysis should consider this aspect.

6. *REFERENCES*

Archuleta, J., Barr, S., Clements, W.E., Gedayloo, T., and Wilson, S.K., 1978: Some atmospheric tracer experiments in complex terrain at LASL. Experimental design and data;
Los Alamos Scientific Laboratory of the University of California, Los Alamos, New Mexico, LA-7198-MS, Vol.I.

Barr, S., Luna, R.E., Clements, W.E., and Church, H.W., Eds., 1977: Workshop on research needs for atmospheric transport and diffusion in complex terrain;
Energy Research and Development Administration Conference 7609160, Albuquerque, NM, September 28-30, 1976.

Defant, F., 1951: Local winds;
Comp. of Meteor., AMS, 655-672.

Flohn, H., 1969: Local windsystems;
in World Survey of Climatology, Vol.II, General Climatology 2, Elsevier Publishing Company, Amsterdam, 139-171.

Fosberg, M.A., Fox, D.G., Howard, E.A., and Cohen, J.D., 1976: Nonturbulent dispersion processes in complex terrain;
Atmos. Environ., 10, 1053-1055.

Gifford, F.A., 1976a: Turbulent diffusion-typing schemes: A review;
Environmental Research Laboratories, Atmospheric Turbulence and Diffusion Laboratory (ATDL), Oak Ridge, Tennessee, September 1976, 1975 Annual Report, 25-43.

Gifford, F.A., 1976b: Atmospheric dispersion models for environmental pollution applications; Environmental Research Laboratories, Atmospheric Turbulence and Diffusion Laboratory (ATDL), Oak Ridge, Tennessee, September 1976, 1975 Annual Report, 312-335.

Grinnell, S.W., Webster, F.X., and Brown, T.S., 1965: Studies on the performance of the rotorod FP sampler; Memorandum Report, No.21 (R)-3, Aerosol Laboratory, Metronics Associates, Inc., Stanford Industrial Park, Palo Alto, Calif.

Hovind, E.L., Spangler, T.C., and Anderson, A.J., 1974: The influence of rough mountainous terrain upon plume dispersion from an elevated source; Symposium on Atmospheric Diffusion and Air Pollution, AMS, Santa Barbara, Calif., September 9-13, 1974, 214-217.

Kao, S.K., Lee, H.N., and Smidy, K.I., 1974: A preliminary analysis of the effect of mountain-valley terrains on turbulence and diffusion; Symposium on Atmospheric Diffusion and Air Pollution, AMS, Santa Barbara, Calif., September 9-13, 1974, 59-63.

Leighton, P.A., Perkins, W.A., Grinnell, S.W., and Webster, F.X., 1965: The fluorescent particle atmospheric tracer; J. Appl. Meteor., 4, 334-348.

Pasquill, F., 1961: The estimation of the dispersion of windborne material; Meteor. Mag., 90, 33-49.

Reid, J.D., 1979: Studies of pollutant transport and turbulent dispersion over rugged mountainous terrain near Climax, Colorado; Atmos. Environ., 13, 23-28.

Reiter, R., 1965: Luftverunreinigung und Kleinionendichte in Abhängigkeit von Windströmung und Austausch; Arch. Met. Geoph. Biokl., B, 14, 53-80.

Start, G.E., Dickson, C.R., and Ricks, N.R., 1974: Effluent dilutions over mountainous terrain and within mountain canyons; Symposium on Atmospheric Diffusion and Air Pollution, AMS, Santa Barbara, Calif., September 9-13, 1974,226-232.

Start, G.E., Dickson, C.R., and Wendell, L.L., 1975: Diffusion in a canyon within rough mountainous terrain; J. Appl. Meteor., 14, 333-346.

Stern, A.C., Wohlers, H.C., Boubel, R.W., Lowry, W.P., 1973: Fundamentals of air pollution; Academic Press, New York and London (1973), p. 277.

Tank, W.G., 1976: Comments on 'diffusion in a canyon within rough mountainous terrain'; J. Appl. Meteor., 15, 1114-1116.

Turner, D.B., 1961: Relationships between 24-hour mean air quality measurements and meteorological factors in Nashville, Tennessee; J. Air. Pollut. Control Assoc., 11, 483-489.

Turner, D.B., 1970: Workbook of atmospheric dispersion estimates; Office of Air Programs Publ. No.AP-26 (Revised 1970), United States Environmental Protection Agency, Research Triangle Park, North Carolina.

Whiteman, C.D., and McKee, T.B., 1977: Observations of vertical atmospheric structure in a deep mountain valley; Arch. Met. Geoph. Biokl., A, 26, 39-50.

Whiteman, C.D., and McKee, T.B., 1978: Air pollution implications of inversion descent in mountain valleys; Atmos. Environ., 12, 2151-2158.

Yoshino, M.M., 1975: Climate in a small area: An introduction to local meteorology; Tokyo, Univ. of Tokyo Press.

List of reports pertaining to the
Loisach River Valley tracer field studies

1. Reiter, R., 1974: Boundary layer aerosol transport measurements in a valley system; Final Technical Report, Contract Number DAJA 37-73-C-1806.

2. Reiter, R., 1975: Boundary layer aerosol transport measurements in a valley system; Final Technical Report Part II, Grant Number DA-ERO-124-74-G0054.

3. Reiter, R., and Sladkovic, R., 1976: Boundary layer aerosol transport measurements in a valley system; Final Technical Report Part III, Grant Number DA-ERO-75-G042.

4. Reiter, R., Sladkovic, R., and Müller, H., 1977: Atmospheric dust and aerosol study; 2nd Status Report, Grant Number DAERO-76-G-035.

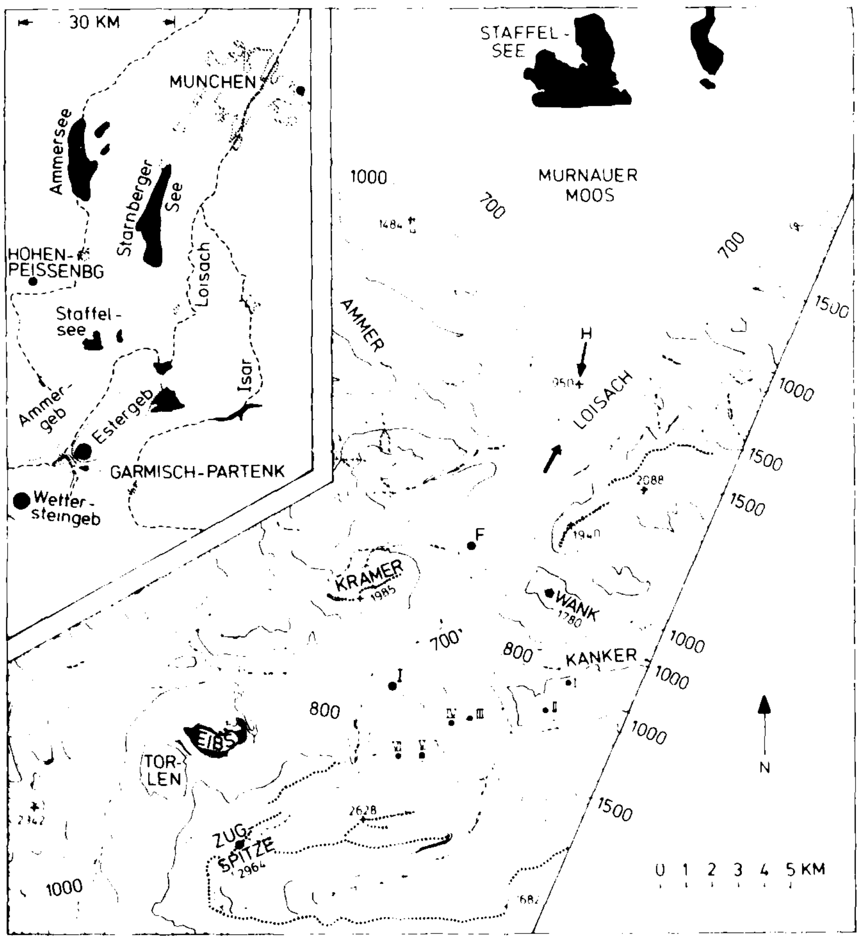


Figure 1: Map of the Loisach River area with contour-lines (m) drawn in 100 m intervals. Tracer was released at the Höhenberg mountain 'H'. Samplers were located at the valley floor and at mountain sites (Wank peak and sites numbered I-VII). The Institute is indicated by the letter 'I'. Dashed lines: Rivers or brooks. Dotted: ridge lines.


aerosol release

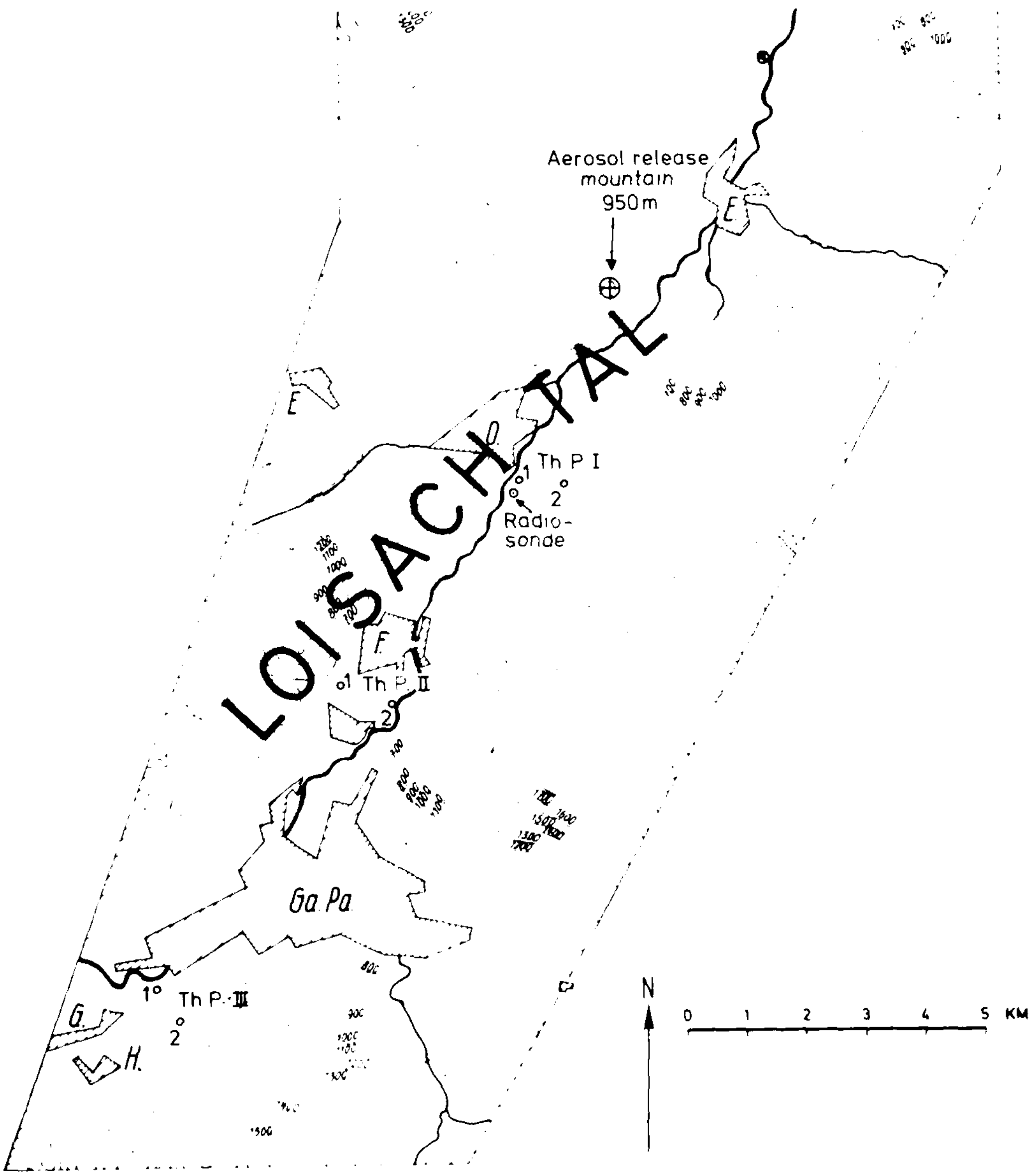


Figure 4: [illegible] theodolite
[illegible] (Th.P. I-III).
[illegible] Base I.

Table 1: General survey on the experimental specifics.

EXPERIMENT				Meteorological conditions		Number of samplers at		
Number	Date	Time (CET)	Duration (min)	Stability class	Wind speed (ms^{-1})	Northern part of the valley	Garmisch basin	Mountain sites
1	13 May 75	12:35	60	D	3.0	18	1	1
2	26 Jun 75	11:00	60	C(B)	6.0	18	1	1
3	7 Jul 75	11:10	60	B	5.5	18	1	1
4	9 Jul 75	11:30	60	C(D)	4.5	13	5	-
5	23 Jul 75	12:04	60	B	6.0	19	-	1
6	28 Jul 75	12:00	40	C(B)	6.5	7	7	5
7	6 Aug 75	11:30	40	C(D)	6.0	4	10	6
8	13 Aug 75	12:00	40	C	5.0	4	10	6
9	11 Nov 75	12:45	40	D	5.5	20	-	-
10	16 Dez 75	13:00	40	-	-	20	-	-
11	8 Mar 76	11:30	60	D	5.0	20	-	-
12	14 Apr 76	10:15	45	C	-	20	-	-
13	28 Jun 76	11:00	45	B(C)	6.0	6	9	5
14	7 Jul 76	10:30	60	B	7.0	8	9	3

Table 2: Mean particle concentration S (particles m^{-3}) at the mountain sites and the valley floor (Garmisch basin) for experiments with three and more samplers at the mountain sites. In the last column, the lateral distance from the ground-level plume axis (time mean path) is denoted by y. All heights in meters above sea level.

EXPERIMENT				Wank	Wamberg	Eckbauer	Bayern-Haus	Garmischer-Haus	Kreuzjoch	Kreuzeck	Garmisch basin	y
Nr.	Date	Duration [min]	Stability class	1780 m	1050 m	1200 m	[illegible]	1330 m	[illegible]	1650 m	[illegible]	[m]
6	28 Jul 75	40	C	-	47	33	73	-	126	118	450	3500
7	6 Aug 75	40	C	26	-	49	158	157	100	144	520	3000
8	13 Aug 75	40	C	20	-	21	90	96	91	114	350	4000
13	28 Jun 76	45	B	-	-	64	193	220	240	256	100	0
14	7 Jul 76	60	B	-	-	0	(130)	(9)		-	80	4000

PRESENTATION OF ALL EXPERIMENTAL DATA

Right side : Tables (I-XIV) - Data Summary

Left side : Figures (I-XIV) - Each figure gives the location of the ground-level plume axis (time mean path) according to the particle counts of the individual samplers for experiments (1-14).

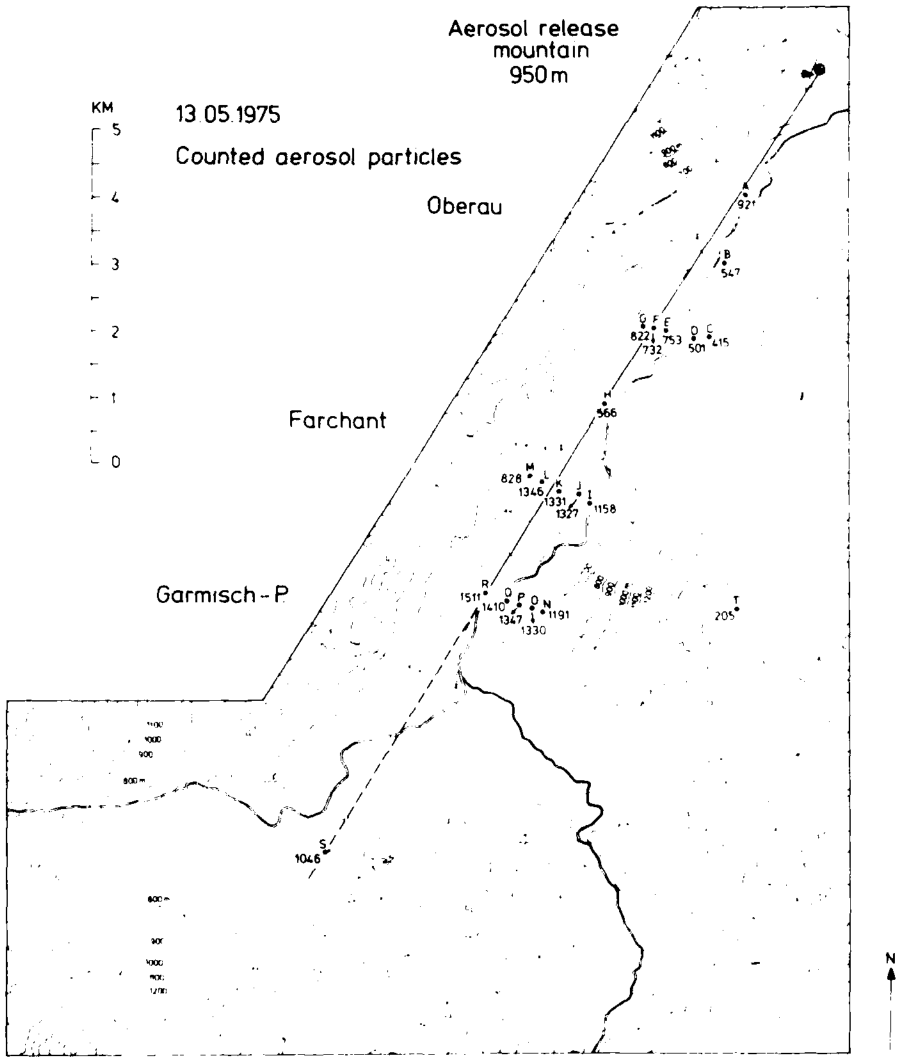

Aerosol release
mountain
950 m
KM
5
4
3
2
1
0
13.05.1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P.
A
921
B
547
G
F
E
D
C
822
732
753
501
415
H
566
M
L
K
J
I
828
1346
1331
1327
1158
R
Q
P
O
N
1511
1410
1347
1330
1191
T
205
S
1046
N

Fig.I

TABLE 1: FP - TRACER EXPERIMENT NO. 1 (FIGS. SEE REPORT NO. 3)

Date	: [illegible]
Duration of emission	: [illegible]
Area	: Northern part [illegible]
Wind direction	: NE [illegible]
Mean wind speed between ground level and 300 m height	: $\bar{u}$ = 3.0 m/s
Cloud cover / height	: 8/10 - 10/10 [illegible]
Atmospheric stability	: Neutral [illegible]
Stability class	: [illegible]

		Wind speed (m/s)	Ascent [illegible]
Oberau	:	$\bar{u}_1$ = 3.0	B - F - G [illegible]
Farchant	:	$\bar{u}_2$ = 3.5	D - H - I - M [illegible]
Mean	:	$\bar{u}$ = 3.0	

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler [illegible] (m)	Number of particles (P) collected [illegible]	Particle (P) concentration 40 min [illegible] (P per m³)	Derived (P) - concentration/10 min S_{10} = S (P per m³)	Particle (P) Flux SU (P/m²s)
A	2150	75	650	300	[illegible]	571	[illegible]	[illegible]
B	3150	375	653	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
C	4200	775	655	[illegible]	[illegible]	257	[illegible]	1104
D	4350	600	[illegible]	[illegible]	501	[illegible]	[illegible]	[illegible]
E	4475	200	[illegible]	291	[illegible]	[illegible]	[illegible]	[illegible]
F	4550	0	[illegible]	288	[illegible]	454	[illegible]	[illegible]
G	4625	-125	662	288	[illegible]	510	[illegible]	[illegible]
H	5000	0	667	283	[illegible]	[illegible]	[illegible]	1500
I	7275	600	677	[illegible]	[illegible]	718	[illegible]	[illegible]
J	7250	400	[illegible]	[illegible]	[illegible]	[illegible]	1177	[illegible]
K	7375	125	[illegible]	[illegible]	1331	[illegible]	[illegible]	[illegible]
L	7375	-175	[illegible]	[illegible]	[illegible]	835	[illegible]	[illegible]
M	[illegible]	-375	[illegible]	[illegible]	[illegible]	513	[illegible]	[illegible]
N	8050	875	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
P	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Q	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

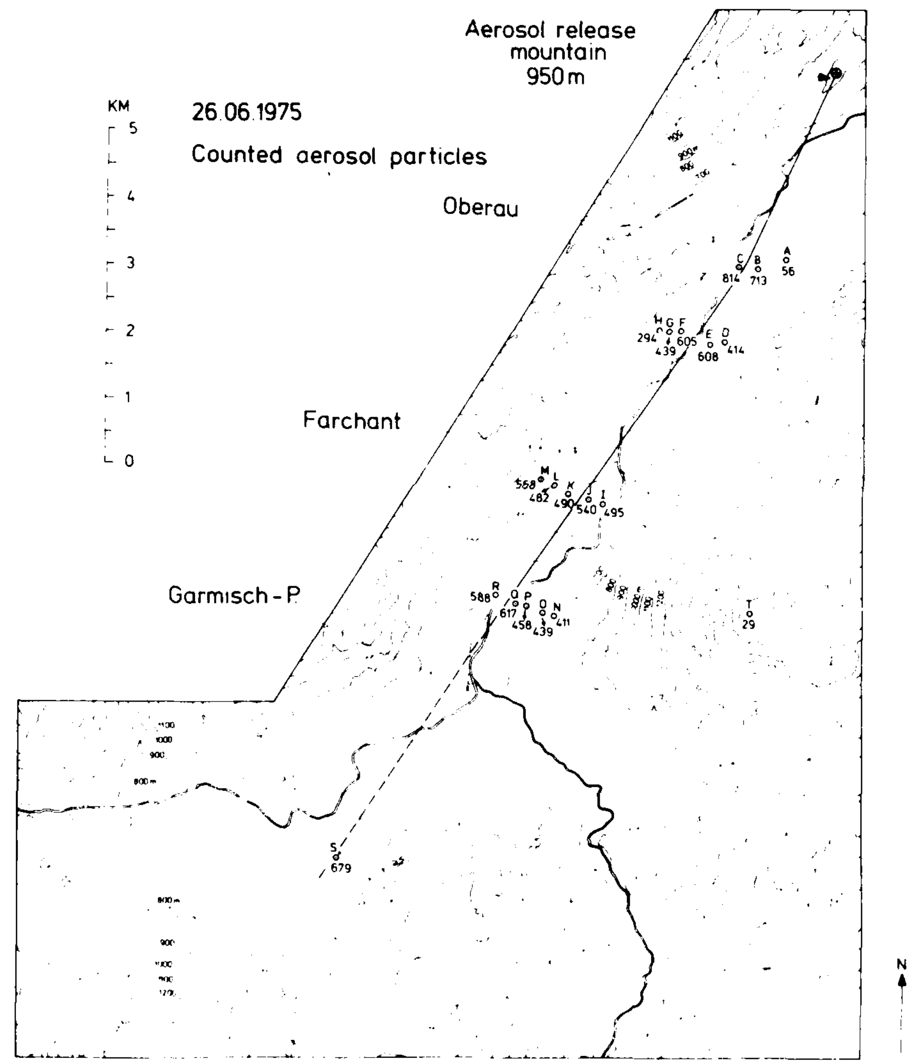

Aerosol release
mountain
950m
KM
5
4
3
2
1
0
26.06.1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P.
C B A
814 713 56
H G F
294 439 605
E D
608 414
M L K J I
568 482 490 540 495
R
588
Q P O N
617 458 439 411
T
29
S
679
N

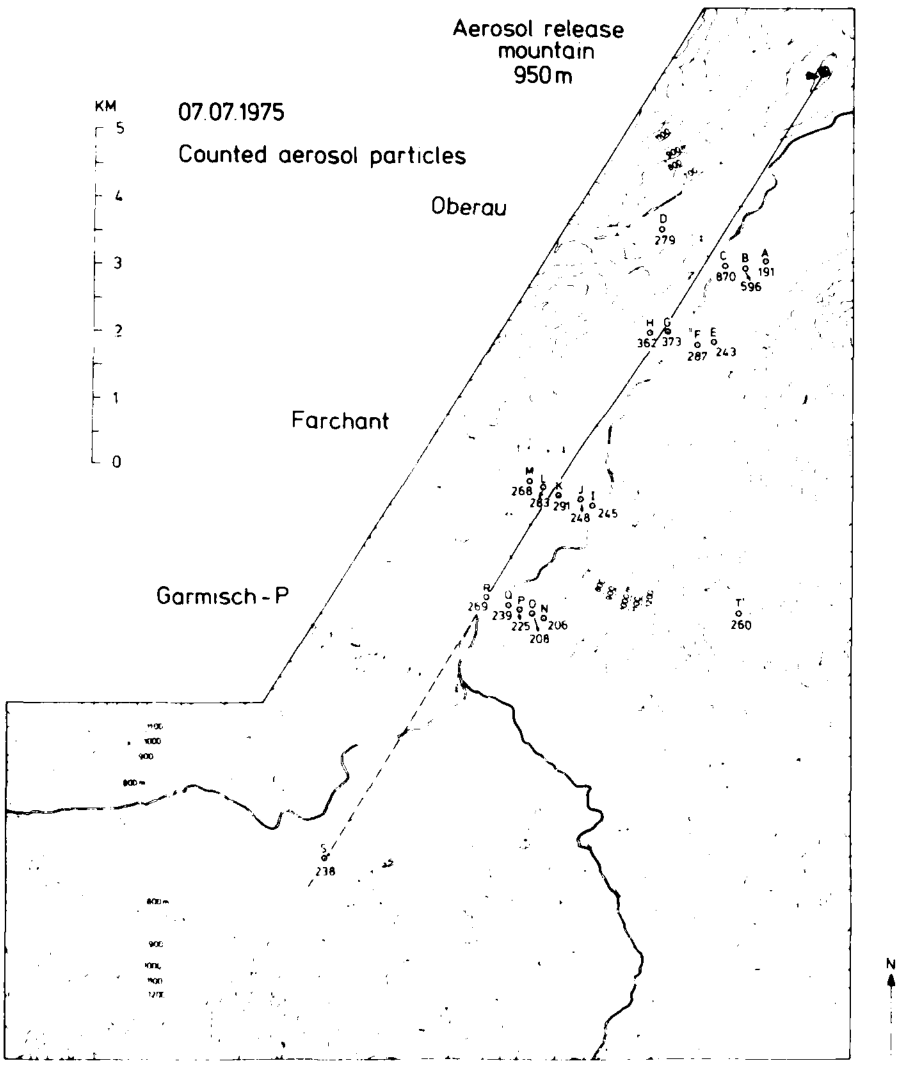
Fig.II

TABLE II: FP - TRACER EXPERIMENT NO. 2 (FIGS. SEE REPORT NO. 3)

Date	:	26 June 1975
Duration of emission	:	11.00 - 12.00 CET (60 min)
Area	:	Northern part of the valley
Wind direction	:	N - NE (Figs. 15, 16)
Mean wind speed between ground level and 300 m height	:	$\bar{u}$ = 6.0 m/s
Cloud cover / height	:	1/10 - 2/10 Cu / 2000 - 2500 m a.s.l.
Atmospheric stability	:	slightly instable to instable (Fig. 17)
Stability class	:	C (B)

		Wind speed (m/s)	Ascent	(Fig.)
Oberau	:	$\bar{u}_1$ = 5.5	B - F - G	(12)
Farchant	:	$\bar{u}_2$ = 6.5	D - I - J	(13)
Mean	:	$\bar{u}$ = 6.0		

Sampler	Distance along axis X (m)	lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected P_{60}	Particle (P) concentration 60 min S_{60} (P per m^3)	Derived (P) - concentration/10 min S_{10} = S (P per m^3)	Particle (P) Flux $S\bar{u}$ (P/(m^2s))
A	2850	500	653	297	56	35	50	300
B	3150	200	653	297	713	442	632	3792
C	3250	- 75	653	297	814	505	722	4332
D	4300	400	655	295	414	257	368	2208
E	4450	250	655	295	608	377	539	3234
F	4525	-250	659	291	605	375	536	3216
G	4625	-375	662	288	439	272	389	2334
H	4700	-500	662	288	294	182	260	1560
I	7325	325	677	273	495	307	439	2634
J	7375	125	677	273	540	335	479	2874
K	7500	-200	678	272	490	304	435	2610
L	7500	-450	683	267	482	299	428	2568
M	7550	-675	686	264	568	352	503	3018
N	9100	725	692	258	411	255	365	2190
O	9150	550	690	260	439	[illegible]	389	2334
P	9225	275	[illegible]	[illegible]	458	[illegible]	406	[illegible]
Q	9300	125	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
R	9350	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	10000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Aerosol release
mountain
950 m
07.07.1975
Counted aerosol particles
KM
5
4
3
2
1
0
Oberau
Farchant
Garmisch - P
N

Fig.III

TABLE III: FP - TRACER EXPERIMENT NO. 3 (FIGS. SEE REPORT NO. 3)

Date	: 7 July 1975
Duration of emission	: 11.10 - 12.10 CET (60 min)
Area	: Northern part of the valley
Wind direction	: N - NE (Figs. 22, 23)
Mean wind speed between ground level and 300 m height	: U = 5.5 m/s
Cloud cover / height	: 1/10 - 2/10 Cu / 2500 m a.s.l.
Atmospheric stability	: instable (Fig. 24)
Stability class	: B

		Wind speed (m/s)	Ascent	(Fig.)
Oberau	:	$\bar{u}_1 = 5.0$	A - E	(20)
Farchant	:	$\bar{u}_2 = 6.5$	C - D - G	(21)
Mean	:	$\bar{U} = 5.5$		

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler H (m)	Number of particles (P) collected D_{60}	Particle (P) concentration [illegible]	[illegible]	[illegible]
A	2850	750	653	297	191	118	[illegible]	[illegible]
B	3100	550	653	297	596	[illegible]	[illegible]	[illegible]
C	3225	275	653	297	870	[illegible]	[illegible]	[illegible]
D	3250	-800	656	294	279	173	[illegible]	[illegible]
E	4250	750	655	295	243	151	[illegible]	[illegible]
F	4425	550	655	295	287	[illegible]	[illegible]	[illegible]
G	4475	100	659	291	373	231	[illegible]	[illegible]
H	4650	-150	662	288	362	[illegible]	[illegible]	[illegible]
I	7550	650	677	273	245	[illegible]	[illegible]	[illegible]
J	7575	425	677	273	248	[illegible]	[illegible]	[illegible]
K	7700	125	678	272	291	[illegible]	[illegible]	[illegible]
L	7725	-150	683	267	283	[illegible]	[illegible]	[illegible]
M	7725	-375	[illegible]	264	[illegible]	[illegible]	[illegible]	[illegible]
N	9375	900	692	258	206	[illegible]	[illegible]	[illegible]
O	9400	725	690	260	208	[illegible]	[illegible]	[illegible]
P	9450	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Q	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
T	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

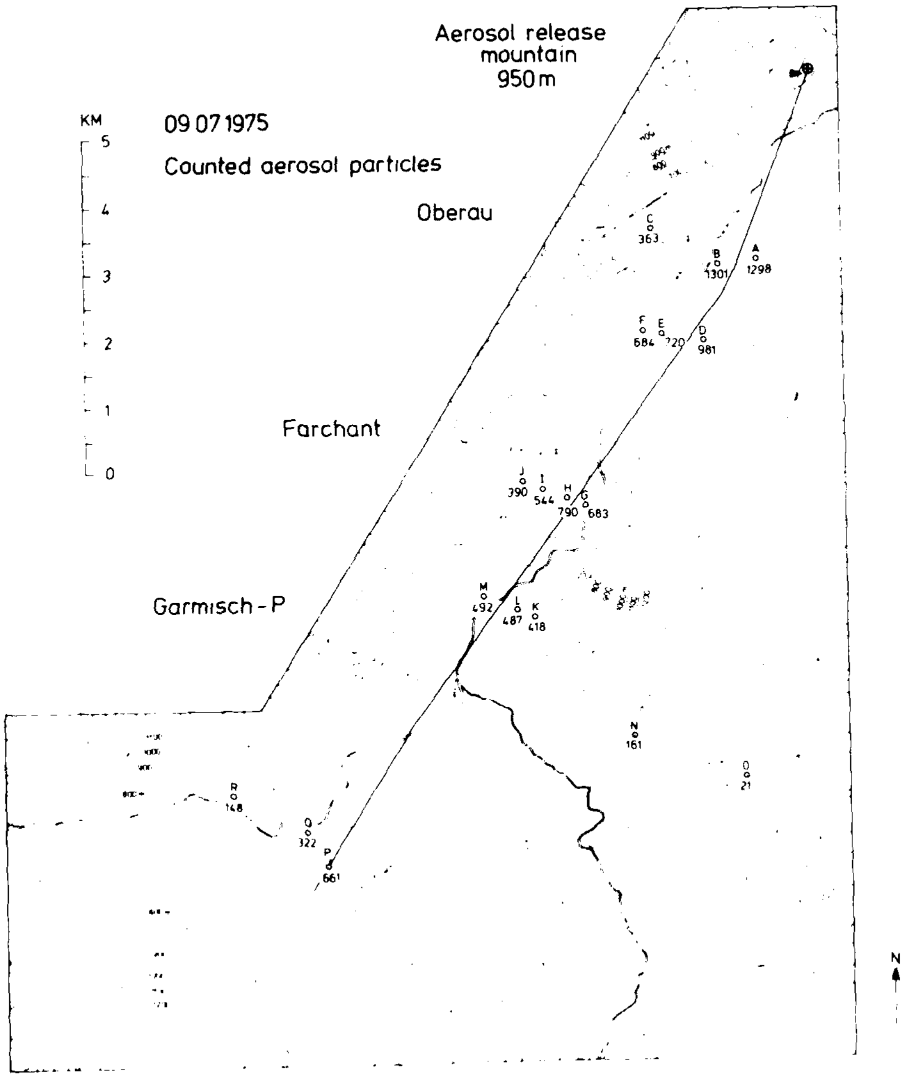

Aerosol release
mountain
950 m
KM
5
4
3
2
1
0
09 07 1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P
C
363
B
1301
A
1298
F
684
E
720
D
981
J
390
I
544
H
790
G
683
M
492
L
487
K
418
N
161
O
21
R
148
Q
322
P
661
N

Fig.IV

TABLE IV: FP TRACER EXPERIMENT NO. 4 (FIGS. SEE REPORT NO. [illegible])

Date	: [illegible] July 197[illegible]
Duration [illegible]	: 11.30 - 12.30 CET (60 min)
Area	: Northern part of the valley [illegible]
Wind direction	: N - NE (Figs. 29,30)
Mean wind speed between ground level and [illegible] height	: U = 4.5 m/s
Cloud cover / height	: 3/10 Sc, Cu and 8/10 Ac / [illegible]
Atmospheric stability	: slightly unstable to neutral (Fig. [illegible])
Stability class	: C (D)

	Wind speed (m/s)	Ascent	(Fig.)
Oberau :	$\bar{u}_1$ = 3.5	B - C - C	(27)
Farchant :	$\bar{u}_2$ = 5.5	B - E - F - E - F	(28)
Mean :	$\bar{u}$ = 4.5		

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected n_{60}	Particle (P) concentration /60 min S_{60} (P per m³)	Derived (P) - concentration/10 min S_{10} = S (P per m³)	Particle (P) Flux SU (P/m²s)
A	2900	250	653	297	1298	805	1151	5180
B	3175	- 250	653	297	1301	807	1154	5193
C	3025	-1375	656	294	363	225	322	1449
D	4300	175	655	295	981	608	869	3911
E	4575	- 375	659	291	720	446	638	2871
F	4700	- 625	662	288	684	424	606	2727
G	7350	175	677	273	683	423	605	2723
H	7400	- 125	677	273	790	490	701	3155
I	7525	- 500	683	267	544	337	482	2169
J	7600	800	686	264	390	242	346	1557
K	4125	[illegible]	692	[illegible]	418	259	370	1665
L	4200	250	688	[illegible]	482	300	432	1944
M	[illegible]	[illegible]	685	[illegible]	[illegible]	306	436	1962
N	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	100	143	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

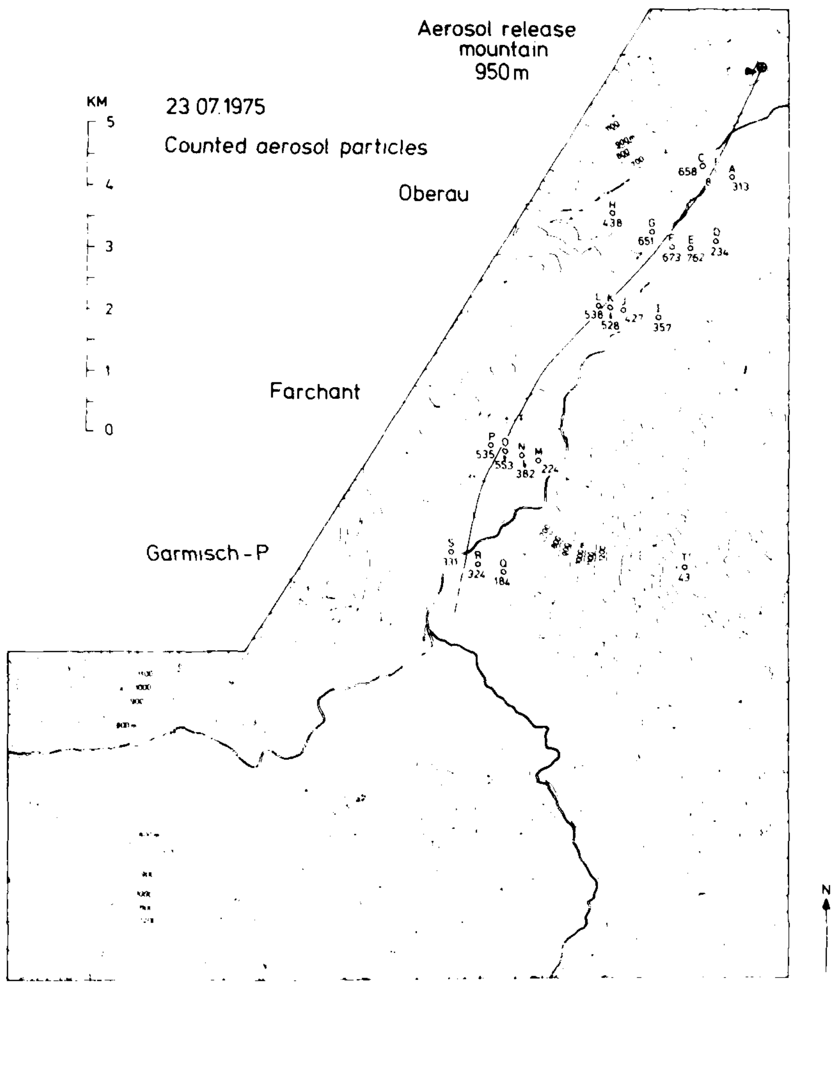

Aerosol release
mountain
950 m
KM
5
4
3
2
1
0
23 07.1975
Counted aerosol particles
Oberau
Farchant
Garmisch - P
658
313
438
651
673
762
234
538
528
427
357
535
553
382
224
324
184
43
N

Fig.V

TABLE V: [illegible] TRACER EXPERIMENT No. [illegible]

Date : [illegible]

Duration of sampling : [illegible]

Area : [illegible]

Wind direction : [illegible]

Mean wind speed between ground level and 500 m height : [illegible]

Cloud cover & height : 1/1[illegible]

Atmospheric stability : [illegible]stable [illegible]

Stability class : [illegible]

	Wind speed (m/s)	Aspect	Fig.
[illegible] :	$\bar{u}_1$ = 5.0	C	[illegible]
[illegible]archant :	$\bar{u}_2$ = [illegible],5	D + E + [illegible] + F	[illegible]
Mean :	$\bar{u}$ = [illegible],0		

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler [illegible] (m)	Number of particles (F) collected D_{60}	Particle (F) concentration 60 min S_{60} (F per m³)	Derived (F) - concentration/10 min $S_{10} = S$ (F per m³)	Particle (F) Flux [illegible] (F/m²s)
A	1825	325	650	300	313	194	277	16[illegible]2
B	1825	75	650	300	837	519	742	4452
C	1825	-175	650	30[illegible]	658	408	[illegible]	3438
D	2725	675	653	297	234	145	207	124[illegible]
E	3050	425	653	297	762	47[illegible]	675	4050
F	3225	150	653	297	673	417	596	357[illegible]
G	337[illegible]	-225	65[illegible]	2[illegible]	[illegible]	404	578	346[illegible]
H	337[illegible]	[illegible]	65[illegible]	2[illegible]	438	272	389	2334
I	[illegible]	[illegible]	[illegible]	[illegible]	357	221	316	18[illegible]
[illegible]	[illegible]	[illegible]75	[illegible]	[illegible]	[illegible]	265	379	22[illegible]4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3[illegible]7	468	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	334	478	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13[illegible]	199	11[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	334	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

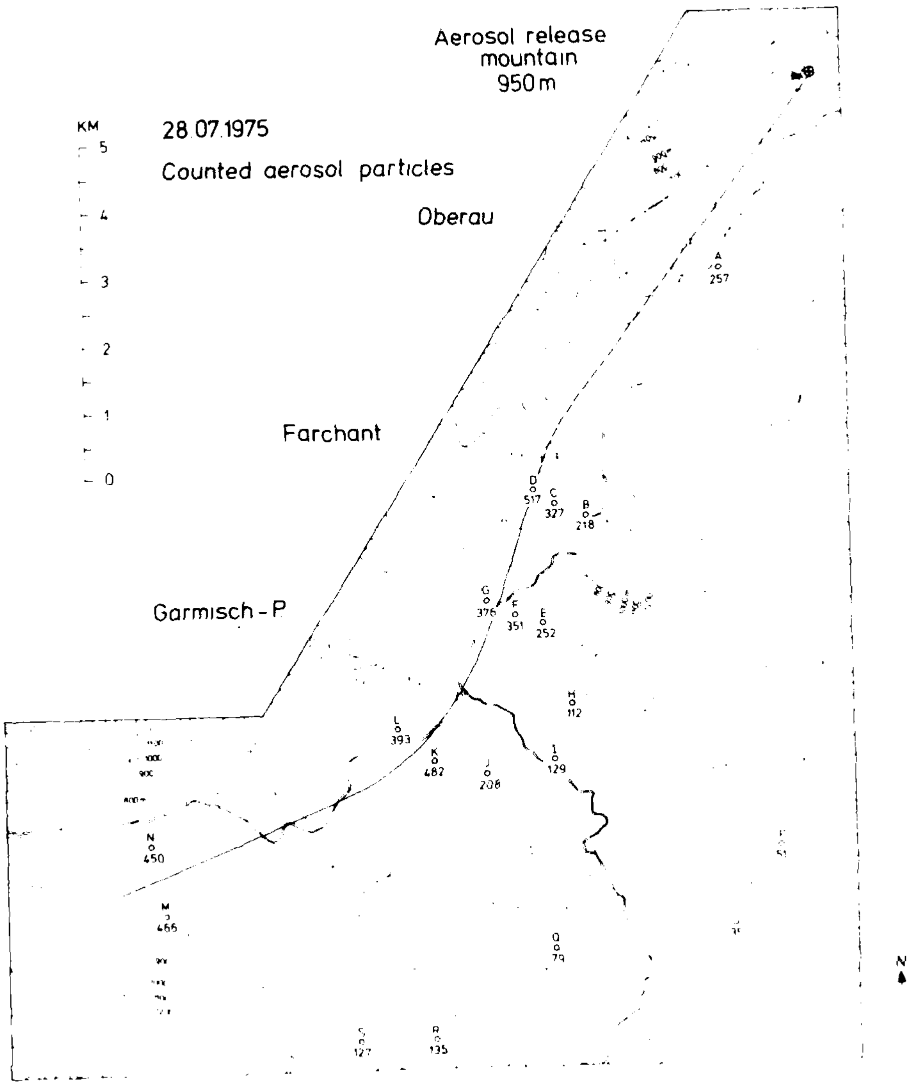

Aerosol release
mountain
950 m
28.07.1975
Counted aerosol particles
KM
5
4
3
2
1
0
Oberau
Farchant
Garmisch-P
A 257
D 517
C 327
B 218
G 376
F 351
E 252
H 112
L 393
K 482
J 208
I 129
N 450
M 466
Q 79
S 127
R 135
N

Fig.VI

TABLE VI: FP - TRACER EXPERIMENT NO. [illegible] [illegible] SEE REPORT NO. [illegible]

Date	: 28 July 197[illegible]
Duration of emission	: 12.[illegible] - 12.4[illegible] [illegible]
Area	: Northern part of the valley, [illegible]
Wind direction	: N - NE [illegible] Figs. 44, 45, [illegible]
Mean wind speed between ground level and 300 m height	: $\bar{u}$ = 6,5 m/s
Cloud cover / height	: 1/10 - 2/10 Cu / 27[illegible] m a. [illegible]
Atmospheric stability	: slightly unstable to unstable [illegible] Fig. 47
Stability class	: C [illegible]

	Wind speed (m/s)	Ascent (Fig.
Farchant :	$\bar{u}_1$ = 7,0	A - B - F [illegible]42
Institute :	$\bar{u}_2$ = 6,5	D - G - H [illegible]43
Mean :	$\bar{u}$ = 6,5	

Sampler	Distance along axis	Distance lateral direction	Altitude above sea level	Height difference Source-Sampler	Number of particles (P) collected	Particle (P) concentration 40 min	Derived (P) - concentration/10 min	Part[illegible]
	X (m)	Y (m)	h (m)	h (m)	D_{40}	S_{40} (P per m³)	S_{10} [illegible] (P per m³)	[illegible]
A	3100	575	653	297	257	239	315	2048
B	7575	850	677	273	218	203	268	1742
C	7525	350	678	272	327	304	401	2607
D	7425	[illegible]	686	264	517	481	635	4128
E	9300	700	692	258	252	234	309	2009
F	9300	275	688	262	351	326	430	2795
G	9200	-200	685	265	376	350	462	3003
H	10175	135[illegible]	780	170	112	104	137	(891)
I	10850	1700	707	243	129	120	158	(1027)
J	11400	1000	707	243	208	193	255	1658
K	11675	300	707	243	482	448	591	3842
L	11675	-425	715	235	393	365	482	3133
M	16150	525	770	180	466	433	572	3718
N	15950	-525	740	210	450	419	553	3595
O	Eckbauer		1200	-250	35	33	44	-
P	Wamberg		1050	-100	51	47	62	-
Q	Bayern Haus		1250	-300	79	73	96	-
R	Kreuzloch		1700	-750	135	126	166	-
S	Kreuzeck		1650	-700	127	118	156	-
T				-	-	-	-	-

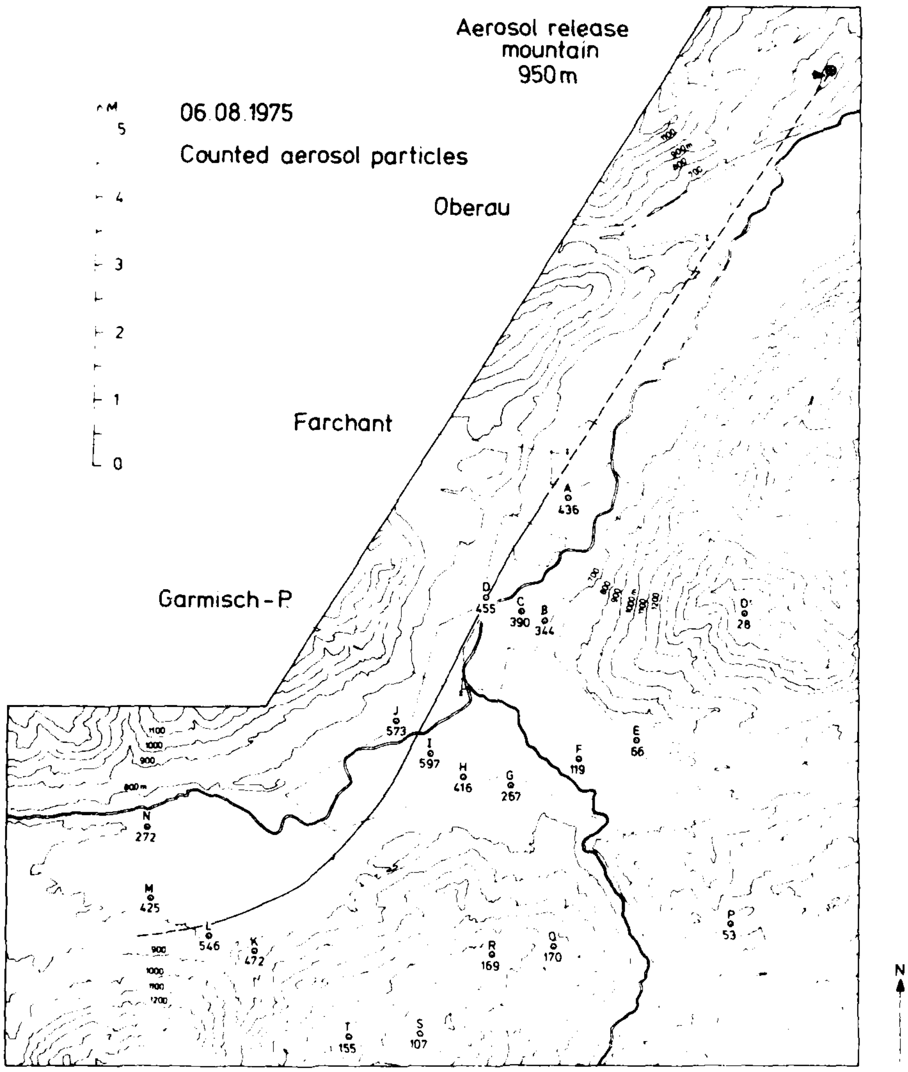

Aerosol release
mountain
950 m
06.08.1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P.
A
436
D
455
C
390
B
344
O'
28
J
573
I
597
H
416
G
267
F
119
E
66
N
272
M
425
L
546
K
472
R
169
Q
170
P
53
T
155
S
107
N

Fig.VII

TABLE VII: FP - TRACER EXPERIMENT NO. 7 (FIGS. SEE REPORT No. 5

Date	: [illegible] August 1975
Duration of emission	: 11.30 - 12.10 CET (40 min)
Area	: Northern part of the valley, Garmi[illegible], Mountain site
Wind direction	: N - NE (Figs. 52, 53, 54
Mean wind speed between ground level and 300 m height	: U = 6.0 m/s
Cloud cover / height	: 3/10 - 4/10 Cu / 2500 m a.s.l.
Atmospheric stability	: Indifferent to slightly instable, base of isothermal layer or inversion 320 m aloft (Fig. 55)
Stability class	: C (D)

		Wind speed (m/s)	Ascent (Fig.)
Burgrain	:	$\bar{u}_1$ = 7.0	R - E (50)
Institute	:	$\bar{u}_2$ = 5.5	D - G - H (51)
Mean	:	U = 6.0	

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected D_{40}	Particle (P) concentration 40 min S_{40} (P per m³)	Derived (P) - concentration/10 min S_{10} = S (P per m³)	Particle (P) Flux SU (P/m²s)
A	7375	300	678	272	436	405	535	3210
B	9250	925	692	258	344	320	422	2532
C	9250	550	688	262	390	363	473	2874
D	9250	0	685	265	455	423	558	3348
E	10150	2925	780	170	66	61	81	(486)
F	10825	2275	710	240	114	111	147	(882)
G	11600	1575	707	243	267	248	327	1962
H	11800	875	707	243	416	387	511	3066
I	11725	275	707	243	592	[illegible]	733	4398
J	11500	-400	715	235	573	533	704	4224
K	15375	575	900	[illegible]	472	439	579	3474
L	15900	150	800	150	540	508	671	4026
M	16675	550	770	180	425	396	521	3126
N	16575	-1600	740	210	272	253	334	2004
O	Wank		1780	830	28	26	34	
P	Eckbauer		1250	230	[illegible]	[illegible]	65	
Q	Bayernhaus		1255	[illegible]	150	15[illegible]	204	
R	Garmi[illegible]		1335	380	1[illegible]	1[illegible]	202	
S	[illegible]		1[illegible]	[illegible]	[illegible]	1[illegible]	13[illegible]	
T	[illegible]		1[illegible]	[illegible]	[illegible]	[illegible]	1[illegible]	

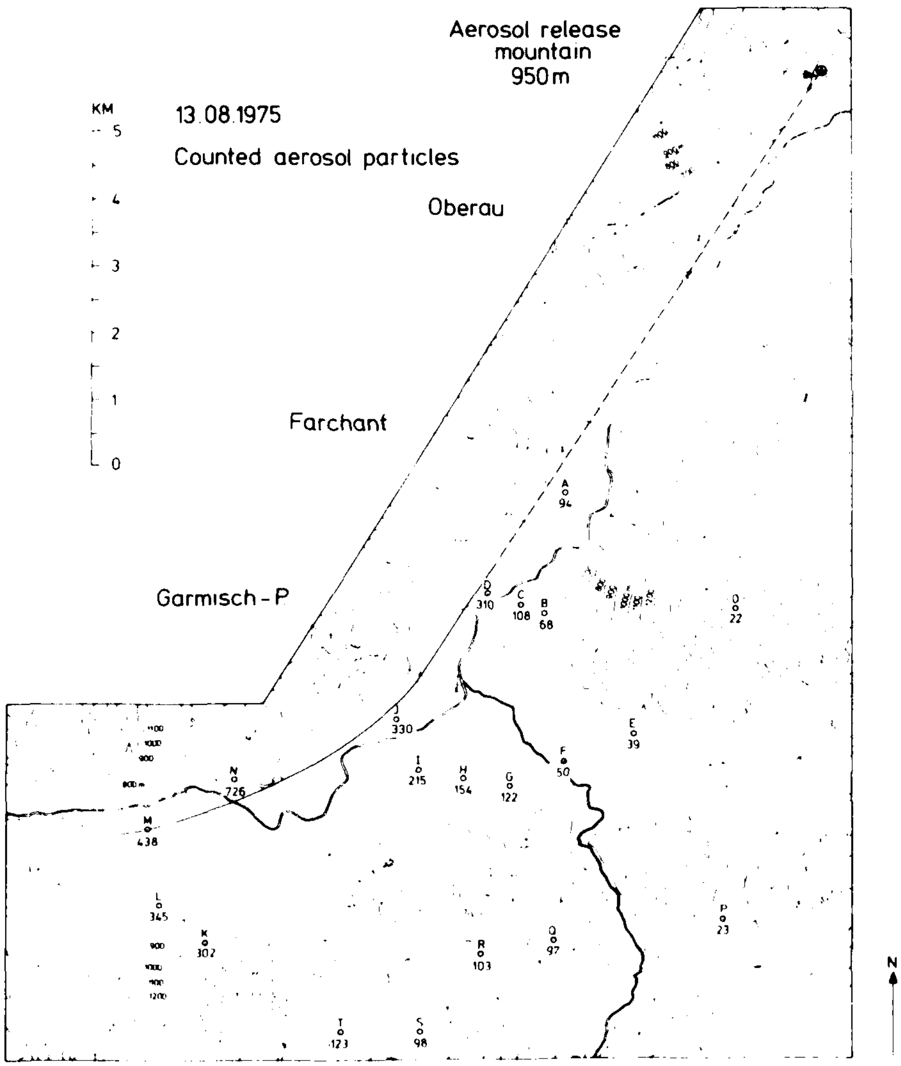

Aerosol release
mountain
950 m
KM
5
4
3
2
1
0
13.08.1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P
A
94
D
310
C
108
B
68
O
22
J
330
E
39
N
726
I
215
H
154
G
122
F
50
M
438
L
345
K
302
R
103
Q
97
P
23
T
123
S
98
N

Fig.VIII

TABLE VIII: FP - TRACER EXPERIMENT NO. 8 (FIGS. SEE REPORT NO. 3)

Date	:	13 August 1975
Duration of emission	:	12.00 - 12.40 CET (40 min)
Area	:	Northern part of the valley, Garmisch basin, mountain site
Wind direction	:	N - NE (Figs. 60, 61, 62)
Mean wind speed between ground level and 300 m height	:	U = 5.0 m/s
Cloud cover / height	:	4/10 - 5/10 Cu / 2500 m a.s.l.
Atmospheric stability	:	slightly instable, base of inversion 625 m aloft (Fig. 59)
Stability class	:	C

		Wind speed (m/s)	Ascent (Fig.)
Burgrain	:	$\bar{u}_1$ = 6.0	B - C - G (58)
Institute	:	$\bar{u}_2$ = 4.0	E - F - I (59)
Mean	:	U = 5.0	

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected D_{40}	Particle (P) concentration 40 min S_{40} (P per m³)	Derived (P) - concentration/10 min S_{10} = S (P per m³)	Particle (F) Flux Sc (P/m²s)
A	7325	275	678	272	94	87	115	575
B	8975	1025	692	258	68	63	83	415
C	9075	675	688	262	108	100	132	660
D	9225	150	685	265	310	288	380	1900
E	9775	3125	780	170	39	36	48	(240)
F	10700	2475	710	240	50	47	62	(310)
G	11250	2075	707	243	122	113	149	745
H	11425	1500	707	243	154	143	189	945
I	11700	975	707	243	215	200	264	1320
J	11500	175	715	235	330	307	405	2025
K	15275	1875	800	150	302	281	371	1855
L	15700	1150	770	180	345	321	424	2120
M	15550	0	740	210	438	407	537	2685
N	14050	-300	800	150	726	675	891	(4455)
O	Wank		1780	-830	22	20	26	-
P	Eckbauer		1200	-250	23	21	28	
Q	Bayern Haus		1250	300	97	90	119	
R	Garmischer Haus		1330	-380	103	96	127	
S	Kreuzjoch		1290	250	98	91	120	
T	Kreuzeck		1650	700	123	114	150	

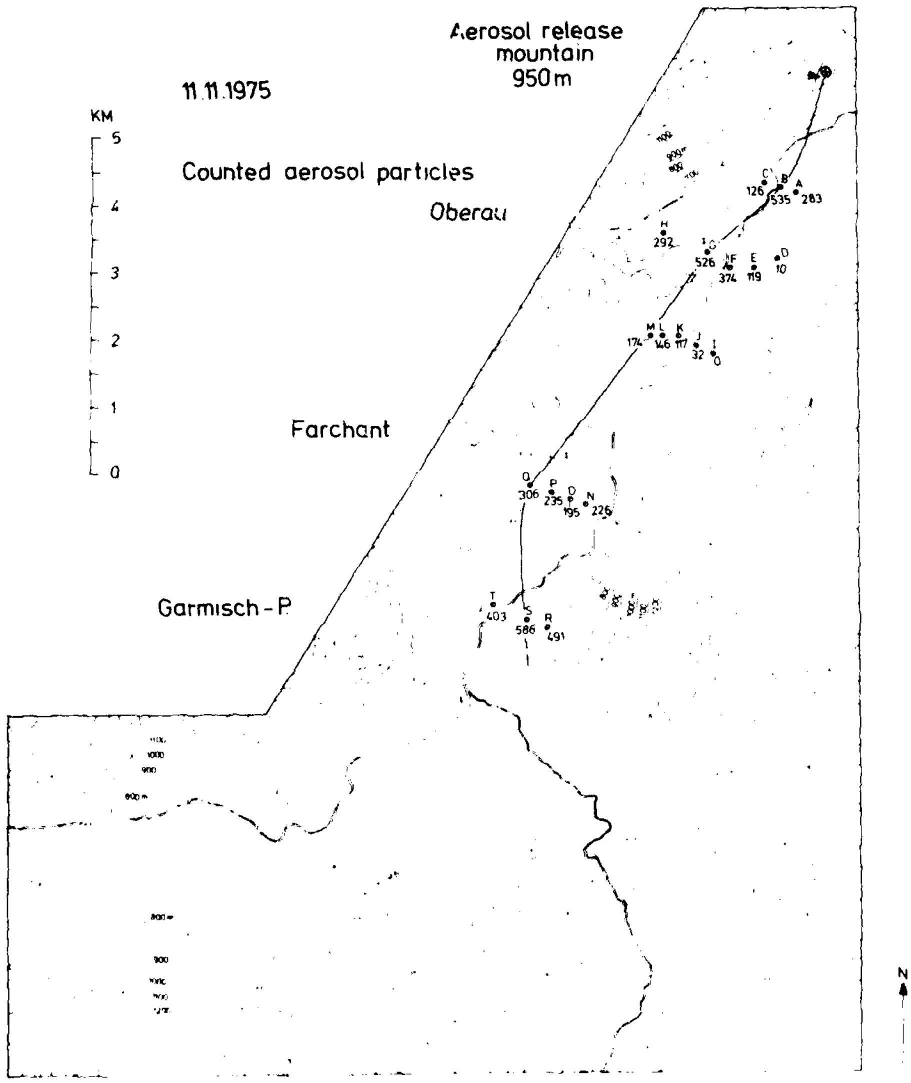

Aerosol release
mountain
950m
11.11.1975
KM
5
4
3
2
1
0
Counted aerosol particles
Oberau
Farchant
Garmisch-P.
N

Fig.IX

TABLE IX: FP - TRACER EXPERIMENT NO. 9 (FIGS. SEE REPORT NO. 4)

Date	:	11 November 1975
Duration of emission	:	12.45 - 13.25 CET (40 min)
Area	:	Northern part of the valley
Wind direction	:	NE (Figs. 5, 6, 7, 8)
Mean wind speed between ground level and 300 m height	:	U = 5.5 m/s
Cloud cover / height	:	Cloudless
Atmospheric stability	:	Neutral, base of temperature inversion between 200 and 400 m (Fig. 9)
Stability class	:	D

		Wind speed (m/s)	Ascent Fig.)
Oberau	:	$\bar{u}_1$ = 5.5	C - G - H (3)
Farchant	:	$\bar{u}_2$ = 6.0	F - I - J (4)
Mean	:	U = 5.5	

Sampler	Distance along axis X (m)	lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler h (m)	Number of particles (P) collected D_{40}	Particle (P) concentration 40 min S_{40} (P per m^3)	Derived (P) - concentration/10 min $S_{10} \equiv S$ (P per m^3)	Particle (P) Flux SU (P/(m^{2}s))
A	1750	225	645	305	283	263	347	1909
B	1850	0	645	305	535	498	657	3614
C	1950	-225	645	305	126	117	154	847
D	2575	725	655	295	10	0	0	0
E	2900	625	650	300	119	111	147	809
F	3175	[illegible]	650	300	374	348	459	2525
G	3300	0	655	295	526	489	645	3548
H	3425	-700	655	295	292	272	359	1975
I	4425	950	660	290	0	0	0	0
J	4475	675	660	290	32	30	40	220
K	4525	375	660	290	117	109	144	792
L	4650	175	665	285	146	136	180	990
M	4775	50	665	285	174	162	214	1177
N	7325	800	665	285	226	210	277	1524
O	7425	575	665	285	195	181	239	1315
P	7500	300	680	270	235	219	284	1590
Q	7625	0	680	280	300	285	376	2068
R	9750	325	680	270	491	452	603	3317
S	9625	0	680	270	586	546	719	3955
T	9375	-450	680	270	403	375	495	2723

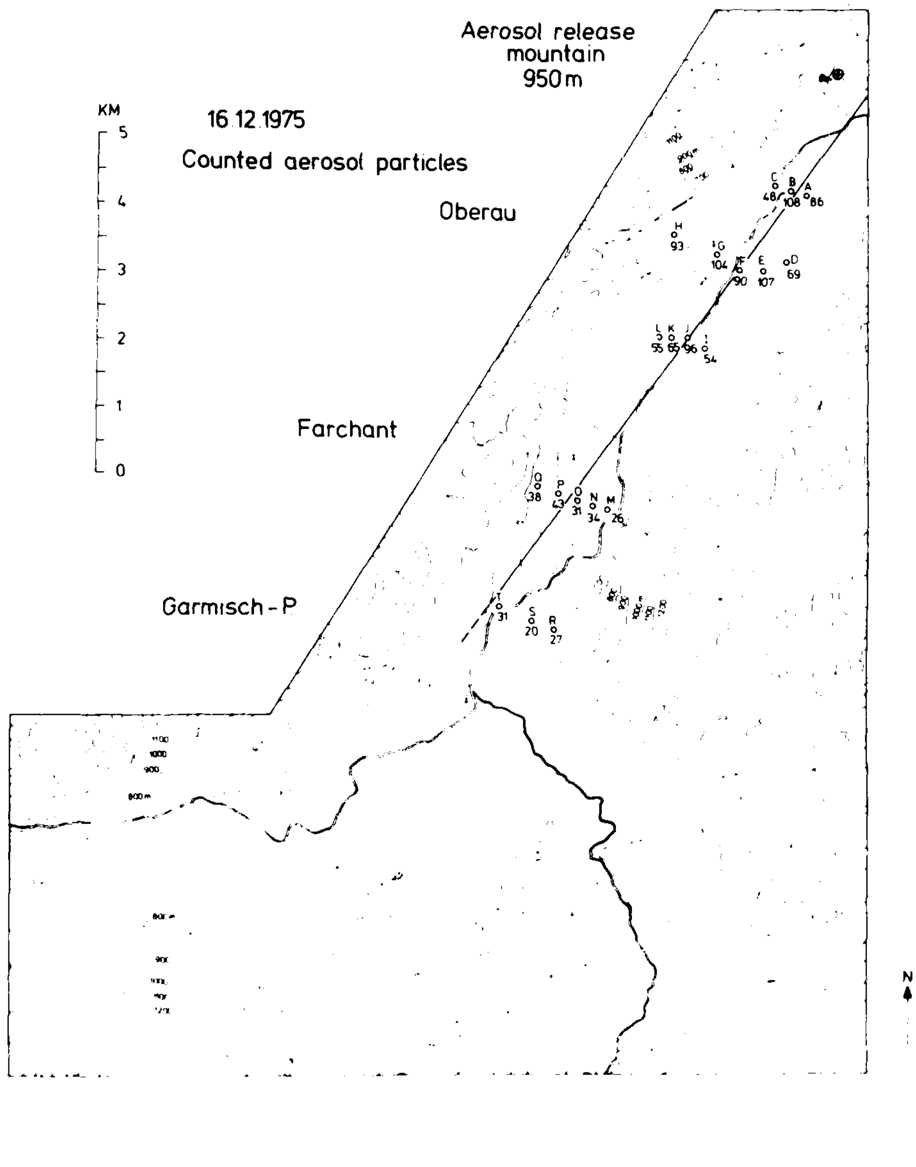

Aerosol release
mountain
950m
KM
16.12.1975
Counted aerosol particles
Oberau
Farchant
Garmisch-P

Fig.X

TABLE X: FP - TRACER EXPERIMENT NO. 10 (FIGS. SEE REPORT NO. 4)

Date	:	16 December 1975
Duration of emission	:	13.00 - 13.40 CET (40 min)
Area	:	Northern part of the valley
Wind direction	:	NE within a shallow (100 m) bottom layer, above that SSW (foehn), see ascent F (Fig. 12)
Wind speed	:	Within the cold, shallow bottom layer weak wind velocities (1-2 m/s), above that - within the foehn current - wind speeds up to 4 m/s at 500 m height, see ascent F (Fig. 12)
Cloud cover / height	:	9/10 - 10/10 Cs, drifting stratus banks in the valley
Atmospheric stability	:	lifted ground based inversion (base between 100 and 300 m), see Figs. 18 and 19
Stability class	:	Undefined

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected D_{40}	Particle (P) concentration 40 min S_{40} (P per m³)	Derived (P) - concentration/10 min $S_{10} = S$ (P per m³)	Particle (P) Flux [illegible]
A	1700	150	645	305	86	80	106	-
B	1775	- 75	645	305	108	100	132	
C	1850	- 300	645	305	48	45	59	-
D	2650	500	655	295	69	64	84	-
E	2975	300	650	300	107	96	127	-
F	3175	0	650	300	90	84	111	
G	3175	- 400	655	295	104	97	128	-
H	3300	-1075	655	295	93	86	114	-
I	4425	300	660	290	54	50	66	-
J	4425	0	660	290	96	89	117	
K	4550	- 200	665	285	65	60	79	-
L	4675	- 350	665	285	55	51	67	
M	7150	575	665	285	26	24	32	
N	7250	350	665	285	34	32	42	-
O	7325	125	665	285	31	29	38	-
P	7400	- 150	680	270	43	40	53	
Q	7500	475	690	260	38	35	46	
R	9050	1000	680	270	27	25	33	
S	9150	[illegible]	680	270	[illegible]	[illegible]	[illegible]	
T	9250	175	[illegible]	[illegible]	21	[illegible]	28	

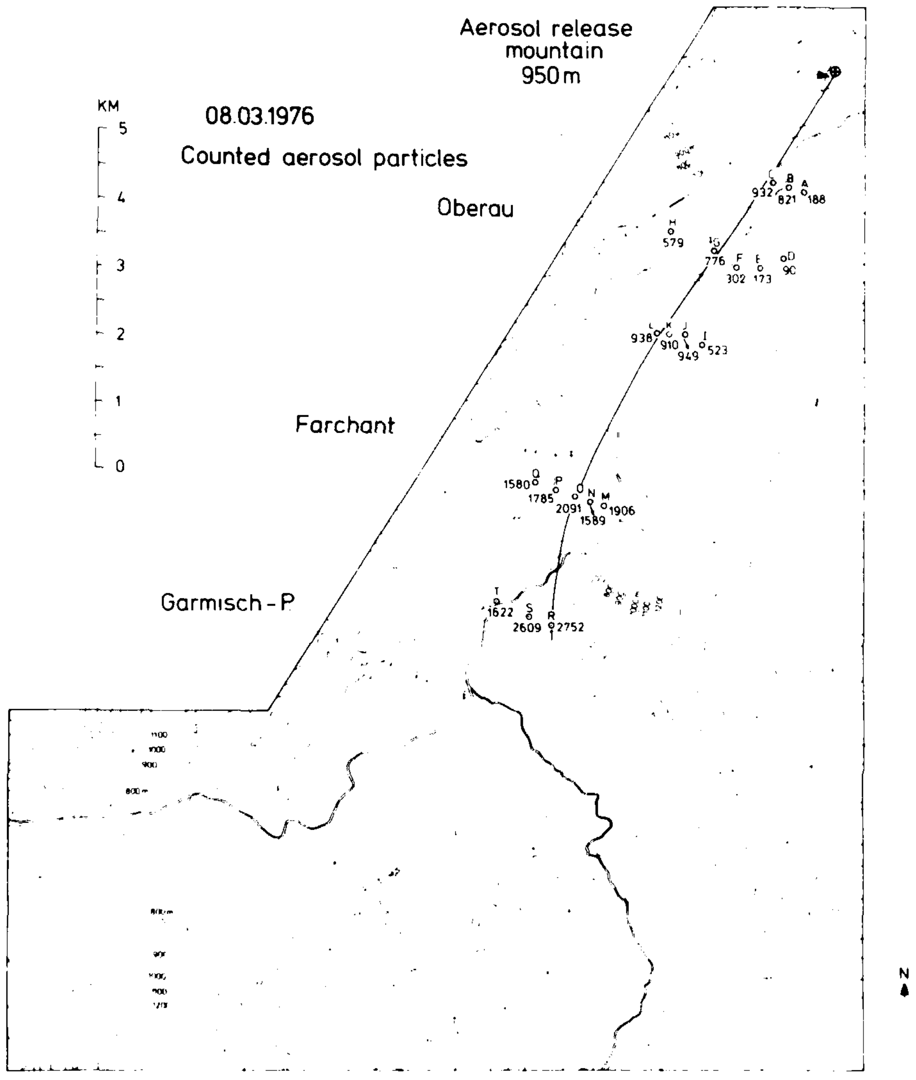

Aerosol release
mountain
950m
KM
5
4
3
2
1
0
08.03.1976
Counted aerosol particles
Oberau
Farchant
Garmisch-P
C
B
A
932
821
188
579
776
F
E
D
302
173
90
938
910
949
523
1580
1785
2091
1589
1906
1622
2609
2752
N

Fig.XI

TABLE XI: FP - TRACER EXPERIMENT NO. 11 (FIGS. SEE REPORT NO. 4)

Date	: 8 March 1976
Duration of emission	: 11.30 - 12.30 CET (60 min)
Area	: Northern part of the valley
Wind direction	: NE (Figs. 23, 24, 25)
Mean wind speed between ground level and 300 m height	: $\bar{u}$ = 5.0 m/s
Cloud cover / height	: 3/10 Sc, 10/10 As / 1400 - 1700 m (Sc), As > 3000 m a.s.l.
Atmospheric stability	: Elevated temperature inversion (base: 300 - 400 m) above a slightly stable bottom layer (Fig. 26)
Stability class	: D

	Wind speed (m/s)	Ascent	(Fig.)
Farchant :	$\bar{u}_1$ = 5.0	B - C - D - E	(22)
Mean :	$\bar{u}$ = 5.0		

Sampler	Distance along axis	Distance lateral direction	Altitude above sea level	Height difference Source-Sampler	Number of particles (P) collected	Particle (P) concentration 60 min	Derived (P) - concentration/10 min	Particle (P) Flux
	X (m)	Y (m)	h (m)	Δh (m)	D_{60}	S_{60} (P per m^3)	S_{10} = S (P per m^3)	$S\bar{u}$ (P/m^2s)
A	1700	525	645	305	188	117	167	835
B	1775	300	645	305	821	509	728	3640
C	1825	75	645	305	932	578	827	4135
D	2650	850	655	295	90	56	80	400
E	2975	625	650	300	173	107	153	765
F	3150	350	650	300	302	187	267	1335
G	3150	- 75	655	295	776	481	688	3440
H	3250	-750	655	295	579	359	513	2565
I	4400	575	660	290	523	324	463	2315
J	4400	275	660	290	949	588	841	4205
K	4550	75	665	285	910	564	807	4035
L	4625	- 50	665	285	938	582	832	4160
M	7250	425	665	285	1906	1182	1690	8450
N	7250	200	665	285	1589	985	1409	7045
O	7250	- 50	665	285	2091	1296	1853	9265
P	7250	-350	680	270	1785	1107	1583	[illegible]
Q	7250	-650	690	[illegible]	1580	980	1401	7005
R	9250	0	680	270	2752	1706	2440	12200
S	9075	-350	680	270	[illegible]	1618	2314	11570
T	8925	-875	680	270	[illegible]	[illegible]	1439	7195

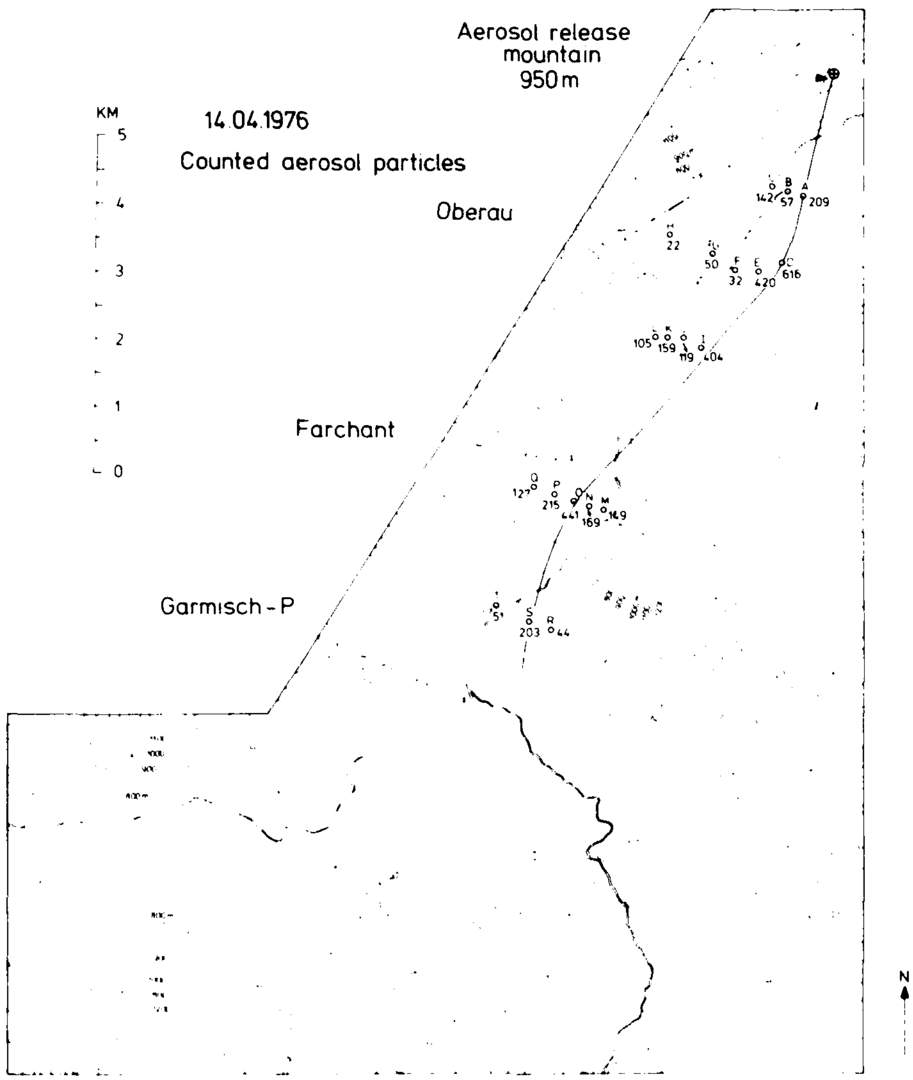

Aerosol release
mountain
950 m
KM
5
4
3
2
1
0
14.04.1976
Counted aerosol particles
Oberau
Farchant
Garmisch-P
N

Fig.XII

TABLE XII: FP - TRACER EXPERIMENT NO. 12 (FIGS. SEE REPORT NO. 4)

Date	:	14 April 1976
Duration of emission	:	10.15 - 11.00 CET (45 min)
Area	:	Northern part of the valley
Wind direction	:	Highly unsteady during the experiment, i.e., NE at the beginning and the end (ascents B and D, Figs. 30, 31), or S in between (ascent C, Fig. 31), respectively
Mean wind speed between ground level and 300 m height	:	Weak velocities of 1-2 m/s (Fig. 29); derivation of a mean value with respect to changing wind directions not meaningful
Cloud cover / height	:	8/10 Cu with subsequent clearing up / 2800 m a.s.l.
Atmospheric stability	:	neutral to slightly instable (Fig. 34)
Stability class	:	C

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler h (m)	Number of particles (P) collected D_{45}	Particle (P) concentration 45 min S_{45} (P per m^3)	Derived (P) - concentration/10 min $S_{10} = S$ (P per m^3)	Particle (P) Flux SU (P/m^{2}s)
A	1800	0	645	305	209	173	234	-
B	1750	- 275	645	305	57	47	63	-
C	1725	- 525	645	305	142	118	159	-
D	2750	0	655	295	616	511	690	-
E	3125	- 250	650	300	420	349	471	-
F	3300	- 500	650	300	32	27	36	-
G	3300	- 925	655	295	50	42	57	-
H	3575	-1575	655	295	22	18	24	-
I	4525	- 125	660	290	404	335	452	-
J	4550	- 425	660	290	119	99	134	-
K	4700	- 600	665	285	159	132	178	-
L	4825	- 750	665	285	105	87	117	-
M	7375	375	665	285	14[illegible]	124	167	-
N	7425	200	665	285	16[illegible]	14[illegible]	189	-
O	7475	- 50	665	285	441	366	494	-
P	7525	- 350	680	270	215	178	240	-
Q	7575	- 650	690	260	127	106	142	
R	9450	325	680	[illegible]	44	37	50	-
S	9375	- 50	680	270	[illegible]	1[illegible]	227	
T	9300	550	680	[illegible]	[illegible]	[illegible]	67	

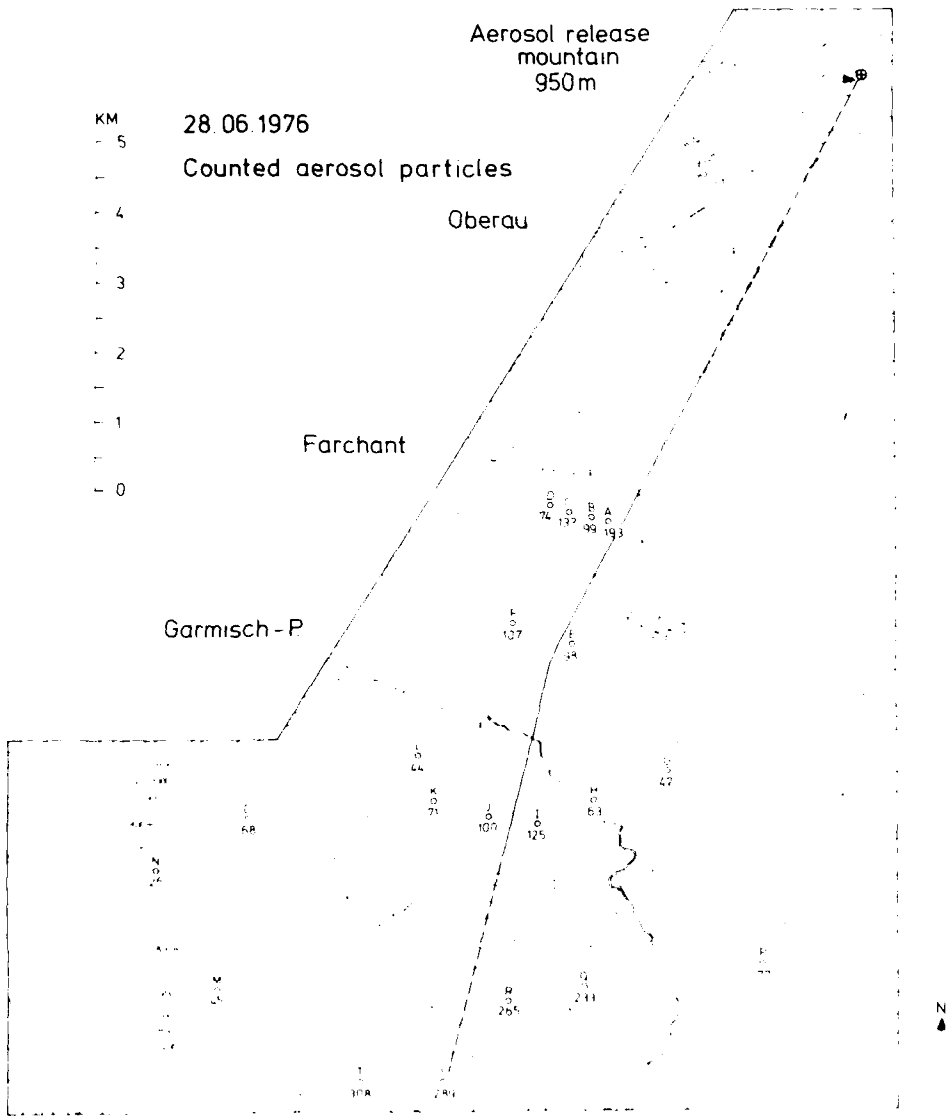

Aerosol release
mountain
950m
KM
5
4
3
2
1
0
28.06.1976
Counted aerosol particles
Oberau
Farchant
Garmisch-P.
N

Fig.XIII

TABLE XIII: FP - TRACER EXPERIMENT NO. 13 (FIGS. SEE REPORT NO. 4)

Date	: 26 June 1976
Duration of emission	: 11.00 - 11.45 CET (45 min)
Area	: Northern part of the valley, [illegible]
Wind direction	: NNE - NE (Figs. 39, 40, 41)
Mean wind speed between ground level and 300 m height	: $\bar{u}$ = 6.0 m/s
Cloud cover / height	: 3/10 - 4/10 Cu / 3000 m a.s.l.
Atmospheric stability	: instable (Fig. 42)
Stability class	: B (C)

	Wind speed (m/s)	Ascent	(Fig.)
Farchant :	$\bar{u}_1$ = 6.0	B - E	(37)
Institute :	$\bar{u}_2$ = 6.0	D - G - H	(38)
Mean :	$\bar{u}$ = 6.0		

Sampler	Distance along axis X (m)	Distance lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected D_{45}	Particle (P) concentration 45 min S_{45} (P per m^3)	Derived (P) - concentration/10 min $S_{10} \equiv S$ (P per m^3)	Particle (P) Flux $S\bar{u}$ (P/m^2s)
A	7325	-200	665	285	193	160	216	1296
B	7375	-425	670	280	99	82	111	666
C	7450	-750	680	270	133	110	149	894
D	7500	-1050	690	260	74	61	82	492
E	9100	175	680	270	98	81	109	654
F	9250	-725	680	270	107	89	120	720
G	10625	1950	780	170	47	39	53	318
H	11275	1050	710	240	63	52	70	420
I	11800	375	710	240	125	104	140	840
J	11850	-325	710	240	100	83	112	672
K	11875	-1125	710	240	71	59	80	480
L	11275	-1500	715	235	44	37	50	300
M	(15175)	(-3450)	820	130	45	37	50	-
N	(13750)	(-4725)	740	210	26	22	30	-
O	(12725)	(-3625)	800	150	68	56	76	-
P	Eckbauer		1200	-250	77	64	86	-
Q	Bayern Haus		1250	-300	233	193	261	-
R	Garmischer Haus		1330	-380	265	220	297	-
S	Kreuzjoch		1700	-750	289	240	324	-
T	Kreuzeck		1650	-700	308	256	346	-

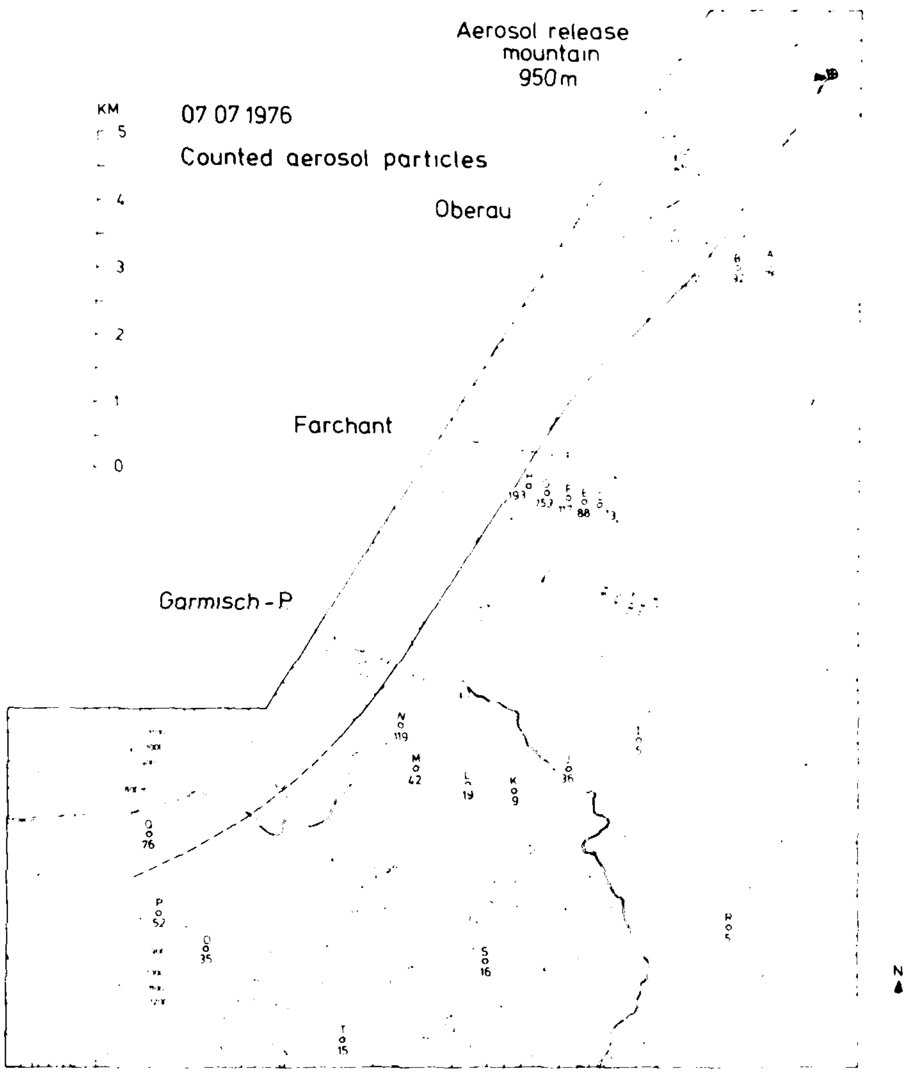

Aerosol release
mountain
950m
07 07 1976
Counted aerosol particles
KM
5
4
3
2
1
0
Oberau
Farchant
Garmisch-P
N
119
42
19
9
36
76
52
35
16
15
88
N

Fig.XIV

TABLE XIV: FP - TRACER EXPERIMENT NO. 14 (FIGS. SEE REPORT NO. 4)

Date	:	7 July 1976
Duration of emission	:	10.30 - 11.30 CET (60 min)
Area	:	Northern part of the valley, Garmisch basin, mountain sites
Wind direction	:	NNE, NE (Figs. 47, 48, 49, 50)
Mean windspeed between ground level and 300 m height	:	$\bar{U}$ = 7.0 m/s
Cloud cover / height	:	1/10 Cu and 4/10 Ci / 3500 m and 10 000 m a.s.l.
Atmospheric stability	:	instable (Fig. 51)
Stability class	:	B

		Wind speed (m/s)	Ascent	(Fig.)
Farchant	:	$\bar{u}_1$ = 6.5	B - D - E - F	(45)
Institute	:	$\bar{u}_2$ = 7.5	G - H - I - L	(46)
Mean	:	$\bar{U}$ = 7.0		

Sampler	Distance along axis X (m)	lateral direction Y (m)	Altitude above sea level h (m)	Height difference Source-Sampler Δh (m)	Number of particles (P) collected D_{60}	Particle (P) concentration 60 min S_{60} (P per m³)	Derived (P) - concentration/10 min $S_{10} \equiv S$ (P per m³)	Particle (P) Flux SU (P/(m²s))
A	2850	800	655	295	76	47	67	469
B	3175	450	650	300	92	57	82	574
C	3250	-650	655	295	77	48	69	483
D	7375	1225	665	285	73	45	64	448
E	7450	1000	665	285	88	55	79	553
F	7525	750	665	285	117	73	104	728
G	7625	450	680	270	153	95	136	952
H	7700	175	690	260	193	[illegible]	172	1204
I	10000	3625	780	170	5	0	0	[illegible]
J	10925	2975	710	240	36	22	31	217
K	11650	2500	710	240	9	[illegible]	[illegible]	[illegible]
L	11650	1900	710	240	19	[illegible]	[illegible]	[illegible]
M	12000	1150	710	240	42	[illegible]	[illegible]	[illegible]
N	11650	600	715	235	119	[illegible]	[illegible]	[illegible]
O	15625	1475	820	130	35	[illegible]	[illegible]	[illegible]
P	16025	700	790	160	52	[illegible]	[illegible]	[illegible]
Q	15600	-450	740	210	76	[illegible]	[illegible]	[illegible]
R	Eckbauer		1200	-250	5			
S	Garmischer Haus		1330	-380	16	[illegible]	[illegible]	
T	Kreuzeck		1650	-700	15	[illegible]	[illegible]	

LMED

-8